
THE HAWAIIAN PLANTERS' RECORD

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A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

In the death of Walter M. Giffard, at the age of 73, there disappeared from our midst a pioneer and a man prominent in the early organization of the Experiment Station. Long associated with the firm of W. G. Irwin & Company, Ltd., he thus became identified with the sugar industry in Hawaii.

As chairman of an organizing committee in 1903, he took a leading part in reorganizing the Hawaiian Sugar Planters' Association Experiment Station and thus took a major part in planning and directing the work of biological control of pests of the sugar cane, and subsequently, as a commissioner on the Board of Agriculture and Forestry of Hawaii, he planned the campaign for the search of parasites of the Mediterranean fruitfly and its introduction into the Territory.

It was while Mr. Giffard was chairman of the Experiment Station Committee that the department of pathology was originated. He also became interested in the production of cane seedlings and urged their propagation. H 109 and some others were derived from these early propagations.

Mr. Giffard showed a deep interest in entomology, and himself was an accurate and painstaking entomologist. He was one of the original members of the Hawaiian Entomological Society founded in 1905. His entomological papers deal chiefly with the native wasps and leafhoppers. His entomological collections, which were very complete, were willed to the Bishop Museum.

Mr. Giffard was a thirty-second degree Mason, and a member of many other organizations.

In This Issue:

Kohala 107 vs. D 1135:

In a test at Hawi, Kohala 107 was compared with D 1135 in a test of over ten repetitions of each variety. The cane was first ratoons, nineteen months old when harvested in July. The field was at an elevation of 325 feet and irrigated.

Kohala 107 proved itself to be consistently better than D 1135, averaging one ton of sugar more per acre, a gain of 21 per cent.

Also, as plant cane in this area, Kohala 107 was superior to D 1135, but not so much. This would indicate Kohala 107 to be a good ratooner.

Overhead Irrigation at Waipio:

A test harvested at Waipio recently showed no differences in yield of cane or sugar from overhead and contour irrigation.

The overhead system required about 25 per cent less water per unit of sugar produced.

The overhead system used 9.1 acre inches of water per ton of sugar, 245,600 gallons. (This is net water, measured at the pump.) The contour system used 11.4 acre inches of water per ton of sugar, 309,000 gallons.

In a later article, types of sprinklers will be discussed.

Cane Pulp as a Carbonaceous Food for Animals:

W. P. Naquin, manager of Honokaa Sugar Company, describes the feed now being used for the work animals of that plantation. This feed is composed of dry, screened bagasse, molasses and soya bean oil meal in the proportion 100-100-50. No other feed is used. It is used at the rate of three pounds for each hundredweight of live weight of animal per day.

The results are reported to be entirely satisfactory, the animals showing a slight gain in weight since this mixture has been put into use.

The cost of this new feed amounts to about 25 cents per animal per day, the average saving being close to $50 per animal per year.

Can We Select Potted Seedlings at Planting Time:

The above question is still unsettled. Answers have been both for and against it by different workers.

The behavior of 5,000 pot seedlings was studied at the Makiki plots. They

were graded as to vigor within one month after planting in the field and again when twelve months old.

The general average grade of the seedlings graded most vigorously as young plants was higher in the final selection than in the other two classes.

The results tend to show that an elimination of 10 to 20 per cent of the very uniform young plants is safe. A higher elimination involves more danger of discarding vigorous plants, but the average vigor of the plants will increase as the standard of selection is raised.

Notes on Javan Termites:

The termite species of the Netherlands East Indies appear to be primarily pests of certain agricultural crops, notably of teak and of *Hevea* rubber, rather than of buildings and wooden structures. Several natural enemies of termites, most of them predators, and only three true parasites, occur in the Malay Archipelago, but none of them is sufficiently effective to warrant introduction into Hawaii. The termite problem here is primarily an urban one, while such termite enemies as are present in Java are adapted to forest conditions.

Suggestions on Experimental Technique:

E. E. Naquin presents an interesting article on the above subject in this issue.

In testing cane varieties he stresses the importance of having the plot extend entirely across the field in order that all soil types may be included. In harvesting, areas in the various soil types should be handled separately, such as the good soils in the bottoms, medium soils on the slopes, and generally poorer ones on the hilltops. He shows that varieties respond very differently as conditions change.

In comparing D 1135 and Uba, for instance, he found D 1135 to be superior on the better soils, but on the thin, poorer types of soil Uba was distinctly better. Had the entire area been harvested as a unit these differences would not have been noted.

In planning the experiment care should be taken to have canes of more or less similar type adjoin each other. It will not do to have Badila next to U. D. 110 because the fast-growing U. D. 110 will soon shade out the Badila.

The same care in covering the various soil types is stressed for fertilizer experiments also. In fertilizer experiments provision must be made for guard rows as the border effect is very marked for at least 10 or 12 feet.

All of these points are well illustrated by a series of five photographs.

Bud Selection:

In this issue we give the results of a bud selection test harvested at Waipio.

A number of what were considered good and poor H 109 progenies were planted with adjacent unselected H 109.

The results show, in this crop, with ten replications of each, that progeny 172 and progeny 68 were consistently better than adjoining unselected H 109.

The test is being continued on the ratoon crop to be harvested next year.

The Mitscherlich Method of Soil Testing and Interpretation of Results:

W. J. Hartung describes the Mitscherlich method of conducting pot experiments for determining soil fertility and gives the methods used for calculating and interpreting the results.

The article does not very well lend itself to abstracting because, although somewhat long, it is in the nature of an abstract itself.

We therefore suggest that the article be read by all those interested.

Chemical Control in Construction of Hydraulic Earth-Fill Dams:

A report on an investigation of hydraulic dam construction appears in this issue. Mainland practices in building technic and control operations are described.

A discussion is included which covers the development of the engineering and chemical "control" which is now in operation at the construction of the Alexander Dam of the McBryde Sugar Company, Ltd., at Eleele, Kauai.

Fourth Pacific Science Congress:

In a report on the Fourth Pacific Science Congress, which convened at Batavia and at Bandeong, Java, May 16 to 29, 1929, is given a general account of the sessions and scientific excursions held there, and attention is called to some of the prominent features of the Congress and of the important papers presented.

Third Congress of International Society of Sugar Cane Technologists:

An article is presented listing the names of the delegates who attended the Third Congress of the International Society of Sugar Cane Technologists which was held in Java, June 7 to 19, 1929. The delegates are listed with their titles and addresses under the name of the country they represented. A photograph of each delegate with the exception of three is also shown. The names of many Java members of the Society who took an active part in making the Conference a success are also listed as published in the official program of the Congress.

Walter M. Giffard

By O. H. Swezey

In the death of Walter M. Giffard, June 30, 1929, a man prominent in the early organization of the Experiment Station, H. S. P. A., and who has always had its interests at heart, passed to his reward.

Mr. Giffard came to the Hawaiian Islands in 1875 at the age of 19. He soon (1877) joined the firm of W. G. Irwin and Company, Ltd., and thus became connected with the sugar industry at an early date, and soon rose to prominence during the time that rapid development of this industry was taking place in Hawaii. From bookkeeper he was promoted, in turn, to treasurer, secretary, and finally vice-president, which office he held at the time when W. G. Irwin and Company, Ltd., dissolved, in 1909, and its interests were consolidated with C. Brewer & Company, Ltd. At that time Mr. Giffard retired from official business life, although he was still a director in several of the sugar plantation companies for whom the W. G. Irwin Company had been agents.

Mr. Giffard's special interest in the Experiment Station began in 1903, when, as chairman of an organizing committee, he took the leading part in a reorganization of the Experiment Station during the course of which a department of entomology was created. This new department had become necessary on account of the devastation caused by the sugar cane leafhopper pest (*Perkinsiella saccharicida*), whose introduction from Australia had occurred a few years previously, and which had now become spread throughout the sugar plantations of the islands and was threatening to ruin the industry. Dr. R. C. L. Perkins was chosen to head this new department of entomology, with Messrs. G. W. Kirkaldy and F. W. Terry, who had been connected with the Territorial plant quarantine inspection work, to assist him. In 1904, this entomological staff was increased by the addition of O. H. Swezey, and in 1905 F. Muir was added to the staff. The early work of the department of entomology involved the study of the leafhopper in Hawaiian cane fields, and the introduction of natural enemies of the leafhopper from other lands. Thus was Mr. Giffard instrumentai in the application of this line of entomology to the sugar industry, following the valuable work of Albert Koebele, who had for about ten years been engaged in introducing ladybeetles and other natural enemies for the control of horticultural pests—a method of insect pest control that has continued in practice and has been eminently successful in Hawaii.

It was while Mr. Giffard was the chairman of the Experiment Station Committee that the department of pathology was originated in 1904 and Dr. N. A. Cobb obtained as its head.

Mr. Giffard also became interested in the attempt to produce cane seedlings, and it was due to his urgent appeal that the propagation of seedlings was finally inaugurated in the season of 1904-5. The celebrated H 109 and several other varieties of notable value were derived from these early propagations.

For a long period of years (1903-1923) Mr. Giffard was a commissioner on

the Board of Agriculture and Forestry of Hawaii, of which he was president for three terms. In connection with this he was much concerned with the horticultural interests of the Territory, and was largely responsible for the promulgation of plant quarantine regulations for the purpose of preventing the entry of additional insect pests to these islands. When the Mediterranean fruitfly made its appearance in 1910, it was Mr. Giffard who headed a clean-up campaign in an endeavor to control the pest and lessen the injury to fruit by its maggots. On the failure of this endeavor, Mr. Giffard planned the campaign for the search of parasites and their introduction, which resulted in the introduction of five species of parasites from Africa and Australia, and a subsequent reduction of fruitfly damage.

From Mr. Giffard's interest in the department of entomology during the time he was involved in its organization, and while chairman of the Experiment Station Committee (1903-1907), and his association with the entomologists, he became keenly interested in entomology and took up insect collecting as a recreation. After his retirement from active business he had much time for this, and built up large collections of the native Hawaiian insects, which, in several groups, or important families, were more complete than any other collections in Honolulu. On his death, these were willed to the Bishop Museum.

When the Hawaiian Entomological Society was founded in 1905, Mr. Giffard was one of the original members, and was always a staunch supporter of the society. He was twice president, and contributed numerous papers resulting from his studies of the insects he had collected. Those of notable importance dealt with Hawaiian wasps and leafhoppers, his interest in the latter group having been aroused by reason of the fact that it was a leafhopper pest that had made the occasion for a department of entomology to be organized at the Experiment Station and the part that he had had in this. A closely related group, the Hawaiian Cixiidae, was carefully studied, and a monographic revision of this family by him was published in the Proceedings of the Hawaiian Entomological Society and constituted his most important entomological paper. Many new species of insects were named for Mr. Giffard, a good proportion of them being species discovered by him. Further plans for continuing his studies with Hawaiian insects were cut short by the prolonged illness from which he finally succumbed on June 30, at the age of 73 years.

Mr. Giffard was a 32nd Degree Mason, Knight Templar and Shriner, honorary member of the Honolulu Chamber of Commerce and of the Hawaiian Sugar Planters' Association, fellow of the Entomological Society of London and of the American Association for the Advancement of Science, member of American Association of Economic Entomologists, Biological Society of Washington and Pacific Coast Entomological Society; charter- and life-member of the Entomological Society of America.

Kohala 107 Surpasses D 1135 in Test at Hawi

HAWI MILL AND PLANTATION COMPANY EXPERIMENT 12-V

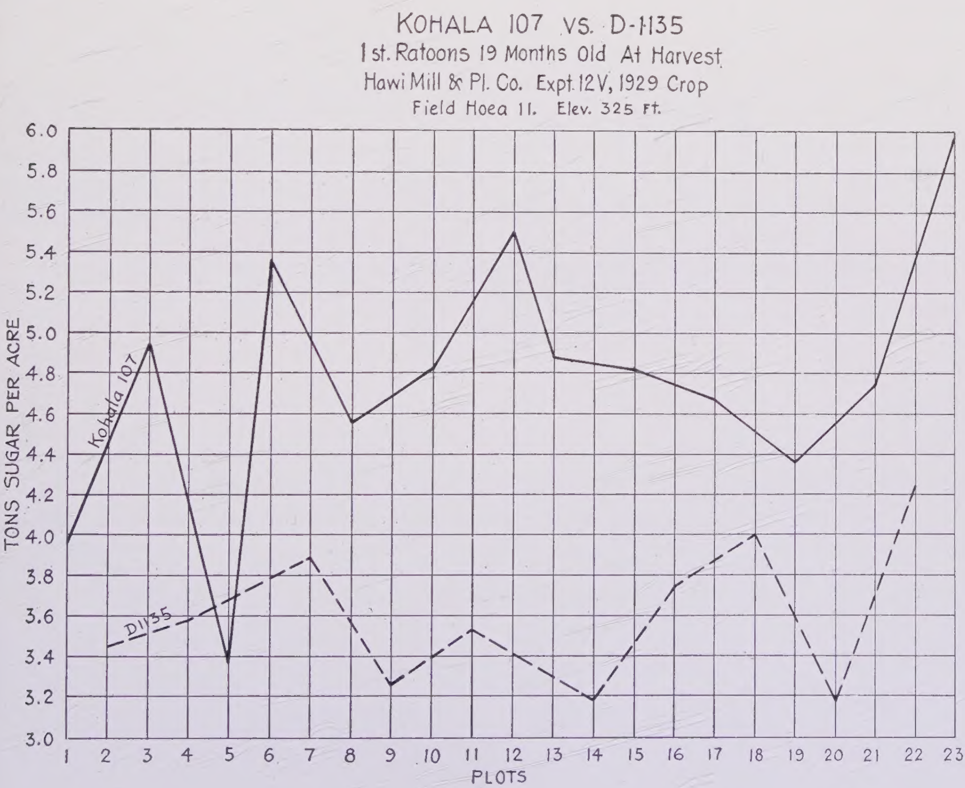
By J. A. Verret

The cane in this test was first ratoons, nineteen months old when harvested in July, 1929. The field was an irrigated one at an elevation of 325 feet. The layout comprised twenty-three plots, thirteen of which were K 107 and ten D 1135. Each plot was two watercourses in size. All plots received uniform fertilization.

K 107 was consistently better than the adjoining D 1135 and averaged over one ton of sugar more per acre than the D 1135. The odds according to Student's Method, that this gain of one ton of sugar is not due to chance, were 9999 to 1. The yields by plots are shown graphically in the accompanying illustration.

The average yields for the plant and first ratoon crops are given below:

	No. of	T.C.P.A.		Q.R.		T.S.P.A.	
Variety	Plots	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
K 107	13	47.6	35.25	9.50	7.46	5.02	4.73
D 1135........	10	45.0	27.47	9.80	7.60	4.60	3.61



In both of these harvests we note the juice of K 107 to be somewhat better than that of D 1135. K 107 gives indications of being a good ratooner.

The behavior of K 107 in rather extensive plantings shows it to be resistant to eye spot, mosaic and red stripe. It closes in somewhat faster than D 1135, and as a rule is not a free tasseler.

The summary of this year's harvest and the detailed yield by plots are given as follows:

Summary of Results

Variety	Area	T.C.P.A.	Per Cent Gain	Q.R.	T.S.P.A.	Per Cent Gain	T.S.P.M.
K 107.........	1.8290	35.248	22.07	7.46	4.73	20.86	.28
D 1135.........	1.3914	27.468		7.60	3.61		.22

PLOT YIELDS

Plot	Tons Cane	Area	T.C.P.A.	Brix	Poln.	Purity	Q.R.	T.S.P.A.
6 K	4.43	.1148	38.6	21.41	18.67	87.2	7.22	5.35
13	3.41	.0926	36.8	20.71	17.92	86.5	7.56	4.87
1	6.33	.2259	28.0	21.19	18.57	87.6	7.24	3.87
15	3.90	.1048	37.2	21.51	17.99	83.6	7.74	4.81
8	4.60	.1462	31.5	22.20	19.44	87.6	6.91	4.56
3	6.54	.1874	34.9	21.59	18.83	87.2	7.16	4.87
17	5.41	.1571	34.4	21.26	18.42	86.6	7.36	4.67
10	3.94	.1146	34.4	21.66	18.88	87.1	7.15	4.81
5	2.84	.1167	24.3	21.36	18.71	87.5	7.19	3.38
19	4.92	.1353	36.4	20.69	16.96	81.9	8.34	4.36
21	4.75	.1250	38.0	21.26	17.57	82.3	8 02	4.74
12	5.28	.1276	41.4	21.46	18.25	85.0	7.53	5.50
23	8.12	.1810	44.9	21.23	18.20	85.6	7.51	5.98
Total....	64.17	1.8290						
True Ave...			35.248				7.46	4.73
7 D..........	3.79	.1384	27.4	22.01	19.15	87.0	7.05	3.89
14	2.25	.0939	24.0	20.78	17.99	86.6	7.53	3.19
2	5.03	.2007	25.1	21.72	18.73	86.1	7.27	3.45
16	3.30	.1186	27.8	21.21	18.33	86.4	7.41	3.75
9	3.76	.1541	24.4	21.50	18.25	84.8	7.54	3.24
4	3.96	.1508	26.2	21.94	18.77	85.5	7.29	3.59
18	5.01	.1584	31.6	21.29	17.70	83.1	7.90	4.00
11	2.55	.0971	26.3	21.75	18.45	84.8	7.46	3.53
20	3.63	.1313	27.6	20.56	16.56	80.5	8.67	3.18
22	4.94	.1481	33.4	21.19	17.68	83.4	7.89	4.23
Total....	38.22	1.3914						3.61
True Ave...			27.468				7.60	

P. O. J. 2878

P.O.J. 2878 on left, standard canes on right. Seven months old plant cane when photographed on August 14, 1929.

Notes on Overhead Irrigation at Waipio Substation

By F. C. Denison

This year we harvested our first crop grown under overhead irrigation. The overhead system was installed in the first ratoon crop, the plant crop having been raised with the contour system. In Fig. 1 a plan of the layout is shown giving the various sizes of pipe and the spacing of laterals and sprinklers. The spacing which we used was based on results of work done by us at the Oahu Sugar Company's baseball park where we determined the distribution and the discharge of water for varying pressures. Fig. 2 shows the distribution that we obtained in our field when the sprinklers were operated at a nozzle pressure of 30 pounds for a period of 12 hours. At the end of the time the depth of water was measured in each tin and recorded as shown in the illustration.

At this point it would be well to bring up the effect of wind on tests and distribution. We have found that much better distribution is obtained if the irrigation is done at night when there is generally less wind than in the daytime. In any layouts for overhead irrigation one must be very careful to take the wind into consideration, especially along the edges of the field. This was clearly brought out in our layout. We should, from our distribution figures, get enough water along the roadside of our layout to give a thorough irrigation, but we did not. In the laterals where the sprinklers are 36 feet from the edge of the field the distribution against the wind was poor and we had spots with insufficient irrigation. This is now being corrected by installing a sprinkler with greater coverage, or it could be corrected by the addition of two small sprinklers on these laterals. We also found that distribution tests should be repeated several times in order to get reliable data, and where wind is a big factor the tests should be repeated even more than usual.

In order to substantiate our distribution results an attempt was made to check it with soil moisture. This proved to be very discouraging as the effect of various factors over which we had no control caused such varying results that no definite conclusions could be obtained. We were, however, able to get results on some of our moisture work in comparison with the adjoining field, which was irrigated by the contour method. The soil moisture samples were taken to a depth of 4 feet two days before and two days after each irrigation. In the sprinkler field seven borings were taken spaced 10 feet apart between two sprinklers in adjoining laterals while in the contour field borings were taken in various watercourses, being careful to keep 30 feet from the level ditches and at least 10 feet from the watercourses. In both fields the borings before and after irrigation were taken within a foot of each other. A 3-acre-inch irrigation applied to the overhead field would increase the soil moisture from 26 per cent to 30 per cent. We were able to account for about 55 per cent of the water in the first 4 feet. In the contour field a 3-acre-inch irrigation would increase the soil moisture from 26 per cent to 29 per cent in the first 4 feet. In other words, we were able to account for

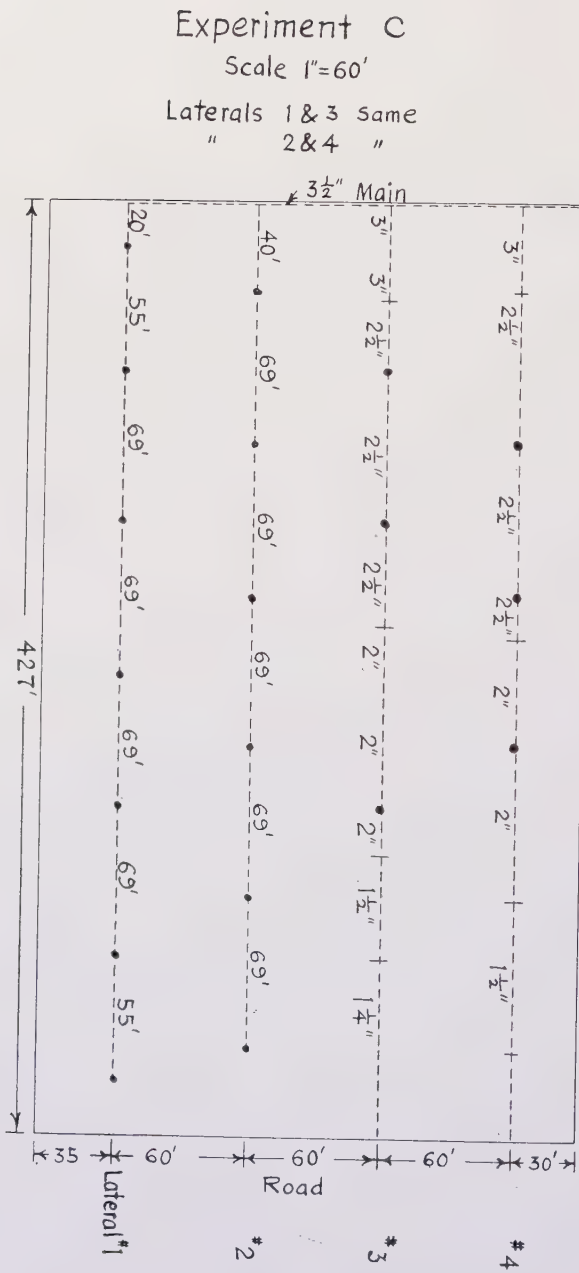

Experiment C
Scale 1"=60'
Laterals 1 & 3 same
" 2&4 "
3½" Main
427'
35
60'
60'
60'
30'
Road
Lateral #1
#2
#3
#4

Fig. 1

about 30 per cent of the 3-acre-inch irrigation. The loss of water by deep percolation in the level ditch and watercourses probably accounts for the difference between the two fields.

The results in yields of the two adjoining fields are tabulated below. In the previous crop, when both fields were under contour irrigation, there was no essential difference between the yields of the two. The water for the overhead field is measured by a Great Western meter as the water enters the sump, while the water for the contour field was measured by a Great Western meter installed at the head of the level ditch.

Field	T.C.P.A.	Q.R.	T.S.P.A.	No. of Irrigations	Ac. In. Rain	Ac. In. Irrigation	Total	Ac. In. T.T.C.	Ac. In. T.T.S.
C overhead	101.82	6.82	14.93	32	29.13	105.94	135.07	1.04	9.1
D contour	103.95	6.92	15.02	32	30.99	140.81	171.80	1.35	11.4

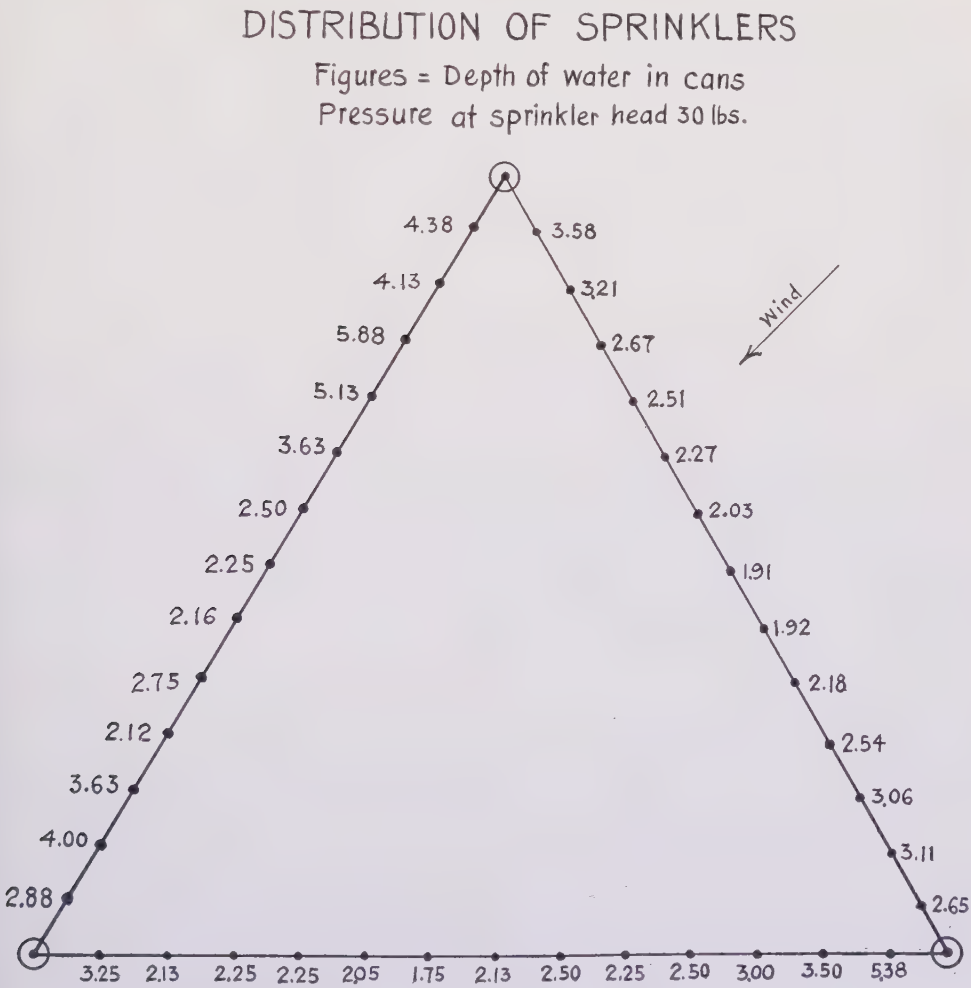


Fig. 2

The results show no significant difference in yields. The sprinkler field used less water and produced more sugar per unit of water used.

In order to compare costs and state whether or not overhead irrigation pays is rather hard with our present outlay. Our pump has a capacity of 200 g. p. m., which with our layout means we are able to irrigate about 1.5 acres as a unit. This means that the labor is higher than for the standard method. If it were possible for us to irrigate from 10 to 20 acres as a unit it would be possible for the same men to handle it equally as efficiently as they do the smaller units. This, however, is only a part of the subject as it is necessary to consider the saving or additional expense for all the operations. The changes in costs which have been noted in our layout are submitted for the reader's consideration.

Plowing: Increased cost for overhead removing lateral pipes and relaying some.

Preparing: Less cost for overhead—deep lines not necessary and lines can be straight as there is no need to follow the contour of the land.

Planting: About the same cost.

First irrigation: Less for overhead as there is no work to be done in building up watercourses.

Irrigation: Less cost for labor in overhead, no level ditch losses.

Weeding: Overhead system requires more weedings, but this can be done by animal or power cultivation.

Stripping: About same as it is necessary to strip along the laterals to facilitate care of sprinklers.

Fertilizing: Fertilizer can be applied by sprinklers very cheaply. We applied 488 pounds A. S. per acre without any serious or noticeable burning effect to the cane.

Ratooning: Advantage for overhead as it is not necessary to repair watercourses and lines.

Harvesting: About the same.

Capital invested: Depreciation on pipe and sprinklers plus initial cost are very large. Additional cost if it is necessary to develop pressure by installation of a pump.

Cane Pulp as a Carbonaceous Food for Animals

By W. P. Naquin

The principal part of feed for animals consists of proteid, carbohydrate, fat, fibre and certain mineral salts and vitamins. For the best results these bodies must be combined in certain proportions, one to the other, and, above all, this combination must be palatable.

On a sugar plantation we have an overabundance of carbohydrate and fibre; in fact sugar cane comes very close to being a pure carbohydrate plant, since all of the sugar, pulp and molasses come under this heading. The sugar, as well as the molasses, is extensively used as a carbonaceous food, both for humans and animals. So far, cane pulp, although it contains 47 per cent digestible carbohydrate, has received but scant attention from farmers and feeders.

A few plantations in the Islands have used the cane pulp as a vehicle for molasses, with indifferent results, the bulk of the carbohydrate and fibre being supplied by cane tops, barley, hay, etc. On account of the distance from the mainland, such materials as barley, hay, etc., are very expensive feed; even the cane tops must be gathered, transported and prepared for feeding, and become a costly ingredient, especially when one considers that their counterparts can be had with the already available cane pulp and molasses.

The composition of cane pulp and molasses, as given by Henry & Morrison in *Feeds and Feeding,* as compared with the expensive imports commonly used in feeding work animals in the Territory, is as follows:

		Digestible Nutrient Per 100 Lbs.				
	Total Dry Matter Per Cwt.	Crude Proteid	Carbo-hydrate	Fat	Total	Nutritive Ratio
Cane pulp	89.9	.5	47.6	3.3	55.5	1 : 110
Molasses	74.3	1.0	58.5	.0	59.5	1 : 58.5
Barley	90.9	9.0	66.8	1.6	79.4	1 : 7.8
Oats	90.9	9.7	52.1	3.8	70.4	1 : 6.3
Barley hay	92.9	4.6	48.2	.9	54.8	1 : 10.9
Beet pulp	90.8	4.6	65.2	.8	71.6	1 : 14.6

Both cane pulp and molasses compare favorably as to the amount of total digestible carbohydrate in most feeds. This carbohydrate in barley and oats is of a starchy nature. The carbohydrate in cane pulp consists mostly of pentosan, sugar and digestible cellulose, integration product of starch, while the carbohydrate of molasses is mostly sucrose and reducing sugars.

In the animal bodies such bodies as starch and cellulose must be disintegrated or broken down to the lower sugars before they can be absorbed by the animal. To what extent these cellulose compounds and the sugars in molasses can be substituted for the starch in a feed is of great economic importance.

In 1927, Honokaa Sugar Company undertook some experiments to learn the

feasibility of utilizing cane pulp, mixed with molasses, solely as the carbonaceous portion of a ration for work animals. To properly balance a ration it was necessary to have a feed high in protein; such a feed we have in soya bean meal.

A balanced ration for hard working animals, using the Wolff & Lehmann standard, was made up as follows:

		Pounds Digestible Matter		
	Dry Matter	Protein	Carbohydrate	Fat
Cane Pulp, 100 lbs.......	89.8	.5	47.6	3.3
Molasses, 100 lbs.........	74.3	1.0	58.5	.0
Soya Bean Oil Meal, 50 lbs.	44.4	19.85	17.3	2.2
Average Composition	83.5	8.54	49.3	2.2

Nutritive Ratio—1 : 6.4

As the cane pulp coming from the mill is too coarse and too moist to use as such, it was necessary to put up a screening and drying plant so as to take the least fibrous portion of the pulp and bring it down to a moisture content that would prevent fermentation. This was easily managed by placing a steel plate 2½ x 5 feet, containing four thousand ⅜-inch holes at the bottom of the main bagasse carrier. The pulp, so screened, is carried to an enclosed cross-carrier through the main flue leading to the smokestack, where the moisture content is reduced to 11 per cent. This is then carried and blown with a suitable blower to a storage room where it is kept until used.

The pulp is mixed with soya bean meal and molasses, in the correct proportions, in an ordinary feed mixer, as feed is required.

Since September, 1927, all of the working animals of the Honokaa Sugar Company, some 400 in number, were placed on the above ration—this being the only feed. Previous to this we had fed a balanced ration consisting of barley, alfalfa meal, cane tops and molasses, with a small portion of cane pulp as a carrier for the molasses.

Although we realized that a gradual change from such a ration to the new one would be desirable, yet in our case we did not feel that the change, from any standpoint, would be sufficiently great to justify prolonging the change; consequently it was made overnight, without any unfavorable reaction.

From then on we have been feeding the ration consisting of 3 pounds of this mixture for each hundredweight of live weight of animal per day, and the results have been entirely satisfactory; not only have we had less sickness in our stables, but there has been a decided improvement in the condition and appearance of our stock.

The cost of this new feed amounts to around 25 cents per animal per day, and the average saving we have made is close to $50.00 per head per year.

At the time of the change we selected twenty animals, which were weighed then and several times thereafter, to see what changes would take place in their physical condition; a list of these weights is given hereunder:

WEIGHT OF TWENTY MULES OF HONOKAA SUGAR COMPANY

	Sept. 18, 1927	Oct. 30, 1927	Dec. 3, 1927	Feb. 5, 1928	Since Sept. 18, 1927 Gain	Loss
1	1,480	1,560	1,560	1,480	...	...
2	1,480	1,520	1,560	1,620	140	...
3	1,420	1,440	1,420	1,420	...	...
4	1,380	1,340	1,380	1,420	40	...
5	1,300	1,320	1,300	1,320	20	...
6	1,260	1,260	1,240	1,280	20	...
7	1,180	1,140	1,200	1,160	...	20
8	1,140	1,200	1,200	1,260	120	...
9	1,100	1,080	1,120	1,040	...	60
10	1,080	1,100	1,040	1,020	...	60
11	960	960	960	980	20	...
12	920	960	940	980	60	...
13	920	1,000	960	940	20	...
14	800	840	820	800	...	...
15	840	840	880	840	...	...
16	800	800	820	840	40	...
17	840	860	860	900	60	...
18	740	780	780	860	120	...
19	720	760	760	800	80	...
20	580	620	600	640	60	...
	20,940	21,380	21,400	21,600	800	140

Twenty animals:	Gain...........	800 pounds
	Loss	140 pounds
	Net Gain ...	660 pounds

From the above table it will be seen that there was very little fluctuation in the weight of the animals from month to month, and as a whole, the twenty animals under observation gained in weight.

This fact, combined with the experience gained through two years feeding, has convinced us that the carbohydrate in cane pulp and molasses answers the bodily requirements of the working animals. When mixed with a suitable proteid body, the feed proves very palatable and the animals take to it readily.

It has also proven satisfactory as an exclusive feed for brood mares. We have several colts of around one year old, whose mothers were given this ration and the young animals appear normal in every way.

The by-products from the beet and pineapple industries have found their niche in the markets of the world, and the writer feels that in cane pulp we have a product similar to these and that eventually its worth will be recognized.

Can We Select Potted Seedlings at Planting Out Time?

By C. G. Lennox

Numerous attempts have been made to answer this question. Answers have been given both in the affirmative and the negative. Dr. O. Posthumus (1) cites experiments where ten very vigorous and ten weak seedlings were selected from a single lot. The results at maturity showed no correlation with the early selection. Y. Kutsunai (2) selected 138 large and 138 small seedlings from the same parentage lot. These were planted in four units, a large classification alternating with a small classification. At the end of twelve months the four units were harvested. A partial tabulation of the data follows:

	Large Seedlings	Small Seedlings
Total number of seedlings planted..........	138	138
Total number of sticks harvested............	1034	776
Average weight of cane per stool............	23.8 pounds	15 pounds
Number of seedlings selected as superior....	18	3

His conclusion is: "Selection of seedlings in pots as to size is effective."

In answer to the question: "What percentage of the seedlings, if any, is eliminated before setting out in the field?" San Manuel, Cuba, and Insular Experiment Station, Porto Rico (3), answer 90 and and 95 per cent are eliminated on the basis of vigor, etc. Mauritius, Virgin Islands, Soledad (Cuba), Florida and the U. S. Department of Agriculture Station at Porto Rico report an elimination of from 50 to 75 per cent before planting in the field.

The Problem

The question to be answered is: With what degree of sureness can we eliminate weak-appearing seedlings which are still in pots, and what is a safe percentage to discard? The study was planned to cover the relationship between very weak, medium, and very strong plants at the time of planting to the field and their distribution as inferior, doubtful, and very superior canes when judged by appearance at twelve months. This age is commonly recognized as the optimum time to make selections.

Will most of the seedlings which appear very strong as small plants of eight to ten inches in height still be the superior ones when they are twelve months old?

Terminology

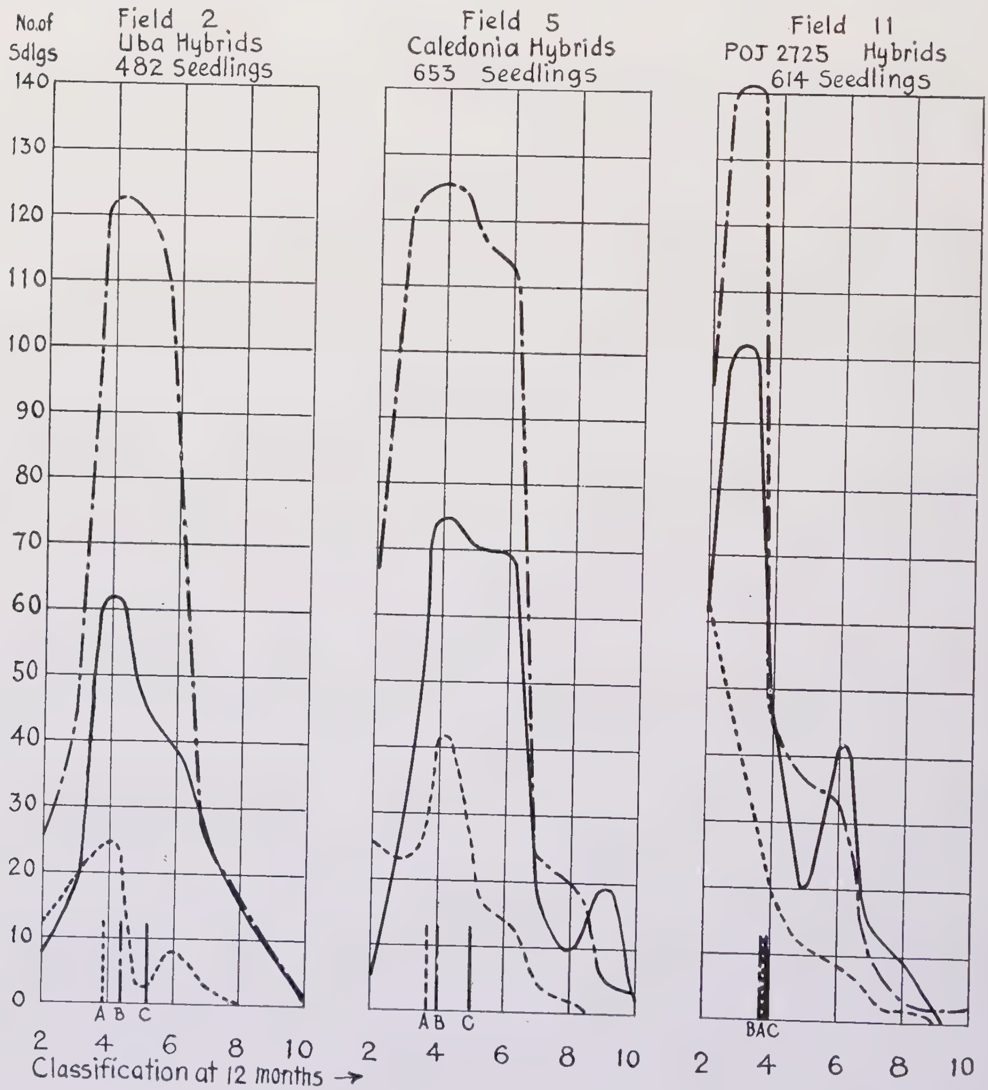
A brief discussion of the terms used in this paper follows:

Vigor—a term used to denote the general growth characteristics of young seedlings. It includes tillering, greenness, speed of growth and general healthiness.

Minus (—)—denotes decided inferiority.

DISTRIBUTION CURVES OF FINAL GRADINGS CLASSIFIED ACCORDING TO GRADING AT PLANTING TIME

Key:-
distribution curve of seedlings which received a grade of + Vigor
" " " " " " " " " = "
" " " " " " " " " − "
A = Mean of − Vigor curve
B = " " = " "
C = " " + " "



Equal (=)—is a classification which is neither decidedly inferior nor decidedly superior.

Plus (+)—denotes decided superiority.

Gradings—the classification of the seedling at the age of twelve months. The most inferior receive a — or 1 grade, while the superior receive + or 5. The other classes are = — 2, = 3, and = + 4. In all cases only the summation of the grades given by two men working separately and independently are given. Thus the lowest classification is 2 and the highest is 10.

Plan of Study

All the seedlings planted at the Makiki plots are given a permanent number on planting. Each seedling is then graded within one month after being transplanted from the pots, being classified as +, =, or — in vigor. Only the very weak ones were considered minus. No selection was made previous to transplanting and no efforts are made to segregate the weak from the strong at the time of planting into the field.

Between the ages of 12 and 14 months, two individuals, working entirely independently of one another, again grade each seedling on the basis of its agricultural qualities. Selection of the best canes is usually based on the grading at this age.

A quantitative study is made of the relationship between the rough classification at planting-out-time and the final selection-grading at 12 to 14 months.

An Interpretation and Analysis of the Results

A separate study was made of each field at Makiki because as a unit each field is more uniform, being generally of the same age when transplanted, the same general parentage, and often the same fuzz lot. A distribution curve of the final gradings was made for the +, = and — "planting-out-time" classification in each field to study the trend of these early gradings. Referring to the accompanying illustration, we find these curves plotted for three typical fields. A study of the distribution of the final gradings within the (+) plus vigor curve shows a tendency to have a general trend to the right. This is borne out when we find the mean (c) of the plus curves always to the right of the other means. In other words, the seedlings which were given a plus grade when planted out show a greater number of good seedlings at the final grading than either of the other groups. Likewise, those which were graded minus vigor at planting out time show a greater proportion of inferior seedlings at the final grading. But a study of the equal curve shows about an equal distribution on either side.

With these curves in mind we would never say that we are justified in selecting only the seedlings showing plus vigor for planting to the field, because there are actually more superior seedlings in the equal vigor group (refer to Table III). Possibly, though, we will be justified in the premise that the seedlings in the minus vigor group could be profitably eliminated as the potted seedlings are planted to the field. A more detailed study of these minus vigor curves therefore ensues.

Minus vigor distribution curves were constructed for all the fields at Makiki. The mean and standard deviation from the mean was calculated for each. These figures, along with the mean + twice the S. D., are tabulated in the following table:

TABLE I

A calculation of the mean and standard deviation of a number of "minus-vigor" curves. Twice the standard deviation includes 95 per cent of all possible observations.

Field No.	Parentage	No. of Seedlings	Mean of minus vigor curve	Standard deviation	Mean plus 2 standard deviation
(1)	(2)	(3)	(4)	(5)	(6)
2	Uba hybrids	29	3.86	±1.15	6.16
4	Caledonia hybrids	32	2.90	±1.38	5.66
5	Caledonia hybrids	47	3.85	±1.43	6.71
7	Caledonia hybrids	88	3.98	±1.75	7.48
12	P. O. J. 2364 hybrids	96	3.58	±1.23	6.04
13	Uba hybrids	55	3.25	±1.22	5.69
14	P. O. J. 2364 hybrids	61	3.24	±1.51	6.26
17	P. O. J. 2364 and Misc.	92	3.55	±1.52	6.59
18	P. O. J. 2364 and Misc.	86	3.04	±1.32	5.68
19	Miscellaneous	30	3.27	±1.26	5.79

Since twice the standard deviation of a mean in a normal curve includes approximately 95 per cent of all the observations composing the curve, we have recorded in column 6 the mean plus 2 S. D. An examination of these figures shows us very few which go above a grade of 6. A seedling with a grade of 6 or 7 would in all probability never be selected for spreading unless it showed a very high Brix. Therefore we might feel safe in assuming that of all the seedlings given a grade minus vigor at planting out time, approximately 95 per cent will never develop into superior seedlings.

Treating the same data as given by the minus-vigor curves on the basis of percentages occurring above or below assumed grades, we have Table II.

TABLE II

A summary of all the "minus-vigor" curves, showing the percentage of seedlings based on the total number in the field, which received the grade of 5 or poorer, 6 or better, and 7 or better.

Field No.	No. of Seedlings In field	Parentage	Percentage of 5 or below	Seedlings receiving a final grade of 6 or above	Seedlings receiving a final grade of 7 or above
(1)	(2)	(3)	(4)	(5)	(6)
2	482	Uba hybrids	5.0%	1.0%	.41%
4	398	Caledonia hybrids	6.8	1.3	..
5	653	Caledonia hybrids	6.0	1.2	.3
7	583	Caledonia hybrids	10.8	4.3	1.4
11	614	P. O. J. 2725 hybrids	22.4	2.6	1.3
12	339	P. O. J. 2364 hybrids	25.1	3.2	1.2
13	357	Uba hybrids	13.4	2.0	.28
14	294	P. O. J. 2364 hybrids	18.0	2.7	.7
17	666	Misc. P. O. J.'s	11.9	2.0	.45
18	460	Miscellaneous	17.4	1.3	.22
19	265	Miscellaneous	9.8	1.5	..
Total	5111		146.6	23.1	5.99
Weighted averages			13.0%	2.1%	.6%

We see from the averages in the above table that should we have eliminated approximately 15.1 per cent (13.0 per cent + 2.1 per cent) of the very poor seedlings at planting out time from the total of 5,111 planted, only about 2.1 per cent of this total would have a grade of 6 or better, and only .6 per cent would have a grade of 7 or better.

Assuming that a final grade of 8 or better is necessary to be assured that a seedling will be kept on agricultural appearance alone, we have tabulated in Table III the actual number of seedlings in each of the vigor groups which received such a grade.

TABLE III

A summary of the number of seedlings in each "planting-out-time" rating group having a final grade of 8 or better.

Field No.	No. of Seedling	No. of seedlings receiving a grade of 8 or better in: Minus-vigor group	Equal-vigor group	Plus-vigor group
2	482	1	29	10
4	398	0	18	12
5	653	1	29	13
7	583	2	23	16
11	614	5	6	5
12	339	3	6	0
13	357	1	20	13
14	294	2	14	4
17	666	3	25	11
18	460	0	5	9
19	265	0	14	9
Totals	5111	18	189	102
Percentage of total		.35%	3.7%	2.0%

From this table we readily see that to make a preliminary elimination greater than of those seedlings in the minus group would be wasteful, for about 94 per cent of all the selected canes fall in these two higher groups, and to retain only the most vigorous seedlings at planting out time would mean the loss of 60 per cent of the superior seedlings which are contained in the other two groups. On the other hand, if it is desired to eliminate the very poorest ones to an extent of 10-20 per cent of the total, then the loss would only be about one superior seedling in every 288.

Conclusions and Summary

A total of 5111 pot seedlings of many different parentages were planted in the plots at Makiki in 1928. No elimination or segregation was made previous to planting.

All seedlings were graded as to vigor within one month after planting. All seedlings were again graded at the age of twelve months by two individuals.

A study of the relationship between the early and final gradings was made. No attempt was made to determine the relationship between an early selection and the canes which show commercial value after years of testing.

The general average grade of the seedlings graded most vigorous as young plants was higher in the final selection than in the other two classes.

An elimination of 10-20 per cent of the very inferior young plants would seem to be a safe practice preceding planting into the field. Such would only occasion the loss of about one superior cane in 288.

Elimination of larger percentages will result in the loss of larger numbers of superior seedlings.

LITERATURE CITED

(1) Posthumus, O. The Selection of Seedlings Before Transplanting Into the Fields. Archief 1929, Part I, No. 13, pp. 379-382.

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Notes on Javan Termites and Termite Enemies

By R. H. Van Zwaluwenburg

The visitor to Java is impressed by the relative unimportance of termites in that tropical island. It is, of course, true that these insects cause considerable destruction of wooden structures and of certain agricultural crops, but their damage is less conspicuous than the writer expected. Although termites are abundant in forested regions, houses in the towns and villages do not seem to suffer to any very great extent. The extent to which natural factors operate to hold white ants in check was the writer's chief field project on his recent visit in Java. Field trips were made as time and opportunity permitted, and numerous local entomologists were consulted on the subject of termites.

There are numerous termite species in Java, among which the following are of major importance:

Calotermes tectonae Damm. This termite attacks only teak. It nests in the trunks of trees usually from twenty to thirty years old, at a height of from 5 to 10 meters above the ground. The formation of the nest causes a gnarled swelling in the trunk, over which the bark cracks. Several of these swellings may occur in a single tree. The various nests may communicate with one another, but are not connected with the ground. Very small holes open to the exterior. Winged individuals are found in the nests just before the rainy monsoon, and swarming takes place when the rains begin. True workers are absent, the nymphs acting as workers. The commercial value of the timber is much reduced by the attacks of this termite, due to the injury to the grain, and to breakage in winds. In some places fully 75 per cent of the trees are attacked. The only control attempted for this pest is thinning out infested trees. This is done in the dry season, before winged adults begin to swarm. The swellings in the trunks are sawed out and burned, because these termites can live for long periods in felled trees. Dr. Kalshoven, of the Instituut voor Plantenziekten at Buitenzorg, has studied the teak termite for several years, and is on the point of publishing his results.

Coptotermes gestroi Wasm. This close relative of the *Coptotermes* occurring in Hawaii, is known from Burma, the Malay Peninsula and the Greater Sunda Islands (Java, Sumatra, Borneo and Celebes). It attacks *Hevea,* kapok, *Ficus,* coconut, mango and various forest trees. The damage to *Hevea* is sometimes severe, especially in the Sumatra rubber plantations, where a closely related species (*C. curvignathus* Holmgren) is the most serious pest of rubber. The damage from *C. gestroi* in Java is said to be comparatively unimportant. Nests are located in and around infested trees, and as with our species, are connected with the ground by means of covered runways. I was unable to see this termite in the field in Java on account of its rarity. Treatment in Sumatra consists of pumping sulfur-arsenic fumes into the nests with a special device, and of burying sawdust mixed with Paris green (100 parts of sawdust to 1 of poison) in the soil about small infested plants. In the Malay Peninsula stress is laid on removing surface timbers, old roots and stumps from the plantations.

Macrotermes gilvus Hagen. This is one of the commonest termites in the Archipelago and is distributed from the Malay Peninsula east to the Celebes and Timor, and north to the Philippine Islands. It builds a low, broad mound and attacks house timbers and dead wood, but not uncommonly feeds in growing sugar cane and in *Manihot* (the tapioca plant). Both in Java and on the island of Luzon the writer was able to observe its work in sugar cane fields. Through the kindness of Dr. R. Brink, group-adviser of the Proefstation voor Suikerindustrie at Pasoeroean, and of Manager van der Haas of Gedaren Plantation near Solo, an inspection was made of the Gedaren fields. Termite damage to cane there was infrequent but some stalks were found which had been killed by this termite's feeding. This occurred on "tegallan" (unirrigated) lands, on fairly light soil, and at Gedaren is said to occur only after the water is shut off from the cane fields for use on the rice "sawahs."

According to Dr. K. W. Dammerman, another, smaller species, *Microtermes jacobsoni* Holmgren, sometimes lives in the upper part of nests of *M. gilvus.*

Natural Enemies

Numerous predators on termites have been recorded from the Malay Archipelago, among them ants, fowls, crows, orioles, starlings, swallows, swifts, lizards, toads, and the scaly ant-eater. Most of these are only occasional feeders which have access to the termites only when some mishap has broken up a nest or a run. Only the ant-eater and one species of ant are known to open up termite structures of their own accord.

Odontoponera transversa Smith is a ground-inhabiting ant, common throughout the Indo-Malayan region. It is capable of breaking open termite runs, from which it bears off the occupants. Wheeler and Chapman say of this ant in the Philippines that "it is especially fond of termites, and is often seen raiding their colonies." Dr. F. X. Williams, who studied this ant at Los Baños, writes as follows: "An unbroken coverway may nevertheless form a fairly effective barrier against *O. transversa,* whose small colonies do not seem equal to the task of holding any of these exceedingly numerous termites in check. When a flight of termites takes place, as was noticed late one afternoon in the case of *Microcerotermes, Odontoponera* captures many winged forms about their carton nests." It is probable that were this ant to be introduced into Hawaii it could not maintain itself against the common *Phidole megacephala* already here.

While at Los Baños in April, I was shown in Dr. Uichanco's laboratory specimens of a muscid fly said to be predaceous on winged termites in flight. These appeared to be identical with *Bengalia latro* de Meij., whose habit of raiding true ants when marching in columns, of their food and young, and whose attacks on flying termites have been noted by the late Dr. Charles F. Baker and by Dr. Williams. Nothing further is known of the habits or biology of this fly, but Fox has recorded the fact that larvae of a species of *Bengalia* occurring in Africa, burrow under the skin of certain mammals, including man, and pupate in the ground.

C. E. Pemberton and D. T. Fullaway having informed the writer of finding

abandoned termite nests in the Dutch East Indies, which contained a certain amount of fungous growth, hopes were cherished of finding a fungus which is parasitic on termites. The examination of termite nests in Macassar (Celebes) and Java failed to reveal any such parasitic fungi. The young of many termite species are fed on the conidia of fungus gardens cultivated within the nest, thus obtaining a food more nitrogenous and easier digested than wood itself. One such fungus, according to Dr. Dammerman, belongs to the genus *Aegerita,* and often assumes a mushroom-like character of growth after the nest has been abandoned. Various termite species cultivate different fungi, and one commonly isolated from fungus-combs in termite nests is *Xylaria.*

Some years ago Dr. J. C. Koningsberger found a fungus, later described as *Cordyceps koningsbergeri* P. and S., which was parasitic on the nymphs of an unnamed termite, and which developed growths resembling grass roots. Dr. S. Leefmans, director of the Plant Disease Institute at Buitenzorg, informed me that this fungus is so rare that it has not been found since its original discovery by Dr. Koningsberger.

Certain species of Phorid flies belonging to the genus *Termitoxenia* are parasitic in the heads of some termites; for example, in a species of *Odontotermes* in Java. Mr. Pemberton some years ago reported such flies in termite heads in the Celebes, but they are rare insects. Their value as parasites is problematical (as in the case of nematodes found in some termite heads), since they apparently produce distortion and not always death in the individual which they attack.

In the Philippines, Dr. F. Silvestri lately found larvae of a Conopid fly similarly parasitic in the heads of soldiers of *Macrotermes gilvus.*

Numerous protozoans have been described from the intestinal tracts of termites, and it was formerly believed that some of them might be parasitic forms. However, recent work has shown that they act as symbionts, aiding the termites in the digestion of the raw cellulose which constitutes their principal food. Experiment has shown that some termite species die in the absence of such intestinal protozoans.

The scaly ant-eater (*Manis javanica* Desm.) or pangolin, a harmless creature, is thus discussed by Dr. Dammerman: "This rather beneficial animal is found throughout southern and southeastern Asia, to the Greater Sunda Islands, Celebes and Palawan in the Philippines. The pangolin conceals itself during the daytime in burrows or in trees, which it ascends with facility. At night it searches for food, which consists of ants and termites, especially of the latter. The termites' nests are broken open with the claws and the inhabitants licked up by the long tongue. . . ."

To sum up: It is the opinion of Dutch zoologists, who have lived with the problem for years, that there is no termite enemy of first-rate importance in the Dutch East Indies. The foregoing notes would indicate that such enemies of termites as are known to occur there cannot be considered valuable enough for introduction into the Hawaiian Islands.

Suggestions on Experimental Technique

By E. E. Naquin

It is a recognized fact that the purpose of an experiment should conform with the principal problems of the plantation involved.

One of the problems which concerns us most in parts of the unirrigated districts is "soil irregularity". On a plantation having, in general, wide variation, perhaps the most valuable experimental layout is one under actual field conditions. The above problem concerns both variety and fertilizer experiments, and the techniques which have to do with experimentation may be discussed under these respective topics.

Variety Experiments

Variety tests as a rule begin with a limited amount of seed cane and preliminary tests usually occupy the time required to accumulate sufficient seed for large size experiments. By that time, providing these early tests were well conducted, the best seedlings should have been selected. These superior canes as a rule must undergo a long period of testing against the standard variety grown locally. By conducting, with the few most promising varieties, large size experiments under general field conditions, much time and labor may be saved.

Fig. 1. Showing how the adjacent row of D 1135 has been smothered out, after the second crop, by the more vigorous variety growing alongside of it. The cane was six months old second ratoons.

Fig. 2. Showing how a four-line check plot of D 1135 has been reduced to two lines after the second harvesting. The cause was due to the two vigorous growing varieties of different type growing on both sides. The cane was six months old second ratoons.

Fig. 3. Showing the difference in the width and height of the outside rows as compared with the inside rows of cane of a four-line variety plot. Note the smothering effect on the inside rows. The cause is due to the outside rows of the more vigorous variety taking advantage over D 1135 growing in the adjacent plots.

1923 Uba Seedlings and P.O.J'S

Fd. # 101 / Plted 7/1/25 / Varieties	Germination	Tillering	Plant Cane — Remarks at (Months) 3	6	9	12	15	3/1/27 Harv.		Tiller-ing 1 Mo.	2 Mo.	First Ratoon — Remarks at (Months) 3	6	9	12	15	9/12/28 Harv.	
D-1135	L VG	L VG	S G	OP VG	OP VG	Cl VG	tl La EX	EX	11.0 124	L b G	L VG	OP VG	OP VG	Cl VG	tl VG	La VG	DC BD VG	12.4 72.1
P.O.J. 36	L G	L VG	VG	OP VG	Cl EX	EX	tl La EX	VG	8.5 74.8	L VG	EX	OP EX	Cl EX	EX	tl EX	La EX	EX	10.3 97.6
D-1135	E EX	L VG	S G	OP G	OP VG	Cl VG	tl La EX	BD ⊙ VG	14.1 86.5	L b F	S L G	S OP G	S OP G	OP VG	Cl tl VG	La VG	RC BD G	13.5 52.1
U-D 1	E VG	E EX	EX	Cl EX	EX	EX	tl La EX	DC VG	8.7 92.5	E EX	EX	T Cl EX	EX	EX	tl EX	La EX	DC EX	10.6 111.7
D-1135	L G	L VG	S G	OP G	OP VG	Cl VG	tl La VG	⊙ EX	14.1 96.8	L b G	L EX	S OP G	OP G	OP VG	Cl tl VG	La VG	RC BD G	12.9 61.7

Grade:
- EX = Excellent
- VG = Very Good
- G = Good
- F = Fair
- P = Poor

Key:
- S = Short
- T = Tall
- tl = Tasseled
- La = Lalas
- DC = Dead Cane
- RC = Rotten Cane
- WS = Weak Stools

Key:
- ⊙ = Suckers
- L = Late
- E = Early
- M = Mosaic
- I = Ileau
- b = Blight
- ES = Eye Spot
- RS = Ring Spot

Key:
- LB = Leaf Burn
- NG = Node Gall
- F = Freckled
- R = Rusty
- BD = Borer Damage
- OP = Open Stand
- Cl = Closed Stand
- G = Grassy

Note: The data in the harvesting column represent the quality ratio and tons of cane per acre.

Fig. 4. Showing a condensed field form used for keeping observation data on variety experiments.

Layout: For testing canes under general field conditions at Honokaa the plots usually extend the entire width of the field or field section. When different types of canes are involved, six to ten rows per plot prove best. The effect that one type of cane may have on another growing in adjacent plots is well illustrated in Figs. 1, 2 and 3.

Observation: This phase of a variety test is perhaps more important, in so far as gaining a knowledge of the varieties is concerned, than the final harvesting data. The more one deals with various types of canes having different agricultural qualities, etc., the greater becomes the importance of observation.

Since varieties grow at different rates, growth measurement may be made a useful tool in determining at what time the growth ceases to be economical.

Observation should include everything that has taken place in the variety plots which may affect the commercial value of the varieties. Perhaps the most effective way of carrying out a systematic method of observation is by having fixed dates for periodic calls on each test. One who is conscientious in his work will find one's self keeping these dates in the same manner that one would keep a business appointment. Of course, besides these formal calls there should exist a flexible program for intermediate visits. Fig. 4 shows a condensed field form which has been used at Honokaa with much satisfaction. Such a form becomes more important when there is a large number of seedlings to be observed.

Harvesting: Plots extending across the field lend themselves well in harvesting by the flume system. The flume lines run across the plots so that the cane can be harvested in sections of desirable dimensions, varying from 50 to 200 feet in length. The field test is harvested in the same fashion as that of the field crop so that very little time is lost. All that is required is close supervision of the field men. Filipinos have proven very satisfactory for this purpose, as they can make themselves readily understood by the laborers of their own race, of which the harvesting gangs are largely composed.

If the purpose of the experiment is to study varieties under actual field conditions and in regard to soil variations, it is essential that cane samples for juice analysis be taken accordingly. Since the flume lines run crosswise in the test plots, it is an easy matter to flume car-lot samples from individual plots, packing the cane in the usual way to the sides of the flume. Using a code system with cane top bundles for delivering the necessary signals to the fluming station, and timing of each sample, makes it possible to flume car-lot cane samples at any distance away from the fluming station.

When the experiment consists of a great number of large size plots, fluming all of the cane from individual plots for the purpose of weighing the cane at the mill is impractical. The delay which is then incurred in the fluming is too great. In that case the usual method of weighing every third bundle of cane in the field is resorted to and proves very accurate, particularly when the bundle system of cutting cane is in vogue. Salter's spring scales are used for this purpose.

Results: Bearing in mind that, in this case, irregularity of the soil is the most important problem in selecting a variety, the results should be studied in that respect. Fig. 5 shows a very effective way of interpreting such results.

Comparing D 1135 and Uba in Fig. 5 it is noted that in good soil, Section A,

Uba yielded 59.8 tons of cane per acre against 42.7 tons for D 1135. Uba gave a quality ratio of 21.8 as compared with 9.1 for D 1135. Owing to its poor juice, it yielded only 2.74 tons of sugar against 4.69 for D 1135. In less fertile soil, Section B, Uba yielded 51.2 tons of cane as compared with 43.3 for D 1135. Uba improved in juice quality as shown by the figure 17.9. D 1135 ratio was the same, 9.1. Uba was again a poor yielder in sugar as compared with D 1135, yielding 2.85 tons against 4.76 tons for D 1135. On thin soil, Section C, the quality of the Uba juice was greatly improved. It gave a quality ratio of 10.4 as compared with 8.4 for D 1135. The yield of 57.8 tons of cane for Uba was as much as it yielded on the better soil. D 1135 tonnage dropped, as shown from the figure 25.2. Uba this time yielded 5.55 tons of sugar against 3.00 tons for D 1135.

Comparing the averages of the two canes, we have the following results: Quality ratio, 15.2; tons of cane, 56.2; tons of sugar, 3.70, for Uba as compared with 8.8, 37.1 and 4.22, respectively, for D 1135. The averages pointed out that Uba was unprofitable for the field in general. However, the data in Section C indicates that Uba is profitable for thin-soil areas. U. D. 1 and U. D. 67 may be compared in the same sphere.

Yield in Tons Per Acre

VARIETIES	Section -"A"-			Section - B -			Section - C -			Averages		
	Q.R.	Cane	Sugar	Q.R.	Cane	Sugar	Q.R.	Cane	Sugar	Q.R.	Cane	Sugar
D-1135	9.1	42.7	4.69	9.1	43.3	4.76	8.4	25.2	3.00	8.8	37.1	4.22
Uba	21.8	59.8	2.74	17.9	51.2	2.85	10.4	57.8	5.55	15.2	56.2	3.70
D-1135	9.8	58.8	6.00	9.8	33.3	3.39	8.1	27.8	3.42	9.8	39.9	4.08
U-D1	11.8	45.9	3.88	11.5	36.8	3.20	8.7	46.8	5.37	10.4	43.1	4.15
D-1135	11.3	63.6	5.62	11.0	30.4	2.76	8.1	20.1	2.48	9.5	38.0	4.00
U-D67	14.4	60.5	4.20	12.7	50.8	4.00	10.5	36.1	3.43	12.5	49.1	3.93
	Level			Slope			Slope (Near Top of Knoll)			Averages		

Field Topography

Fig. 5. Showing variety experiment results in relation to the topography of the test plots.

It is seen from these results that one should not depend too much on general averages. It also points out the importance of conducting variety tests under general field conditions.

Fertilizer Experiments

If the purpose of the experiment is to test different forms of nitrogen fertilizers, phosphate or potash forms, it is no doubt best to use a uniform layout where the results may be computed to a fine point. On the other hand, if it is a plant food test or a quantitative test, experiments under general field conditions are perhaps the most valuable to the plantation.

Layout: The plant food ingredients in fertilizer do not react in the same magnitude in the low-lying areas as they do on the knolls and thin-soil areas. Soil variation should therefore be considered when a layout is being selected.

Ten-row plots extending across the field or field section are proving most satisfactory at Honokaa. The danger of having insufficient guard rows adjacent to each plot can best be realized from Figs. 7, 8, 9 and 10. These photographs were taken in each case on the leeward side of the treated plots so that the question of the wind blowing fertilizer on the adjacent rows of the other plot is obliterated. In Fig. 7 the rows are four feet wide and the plots consist of six rows each.

HONOKAA SUGAR CO. FERTILIZER EXPERIMENT
Field 18. Unirrigated Area - 1100 FT. Elevation
Crop 1927 - D1135 - 4th. ratoon

Tons of Cane Per Acre

Plot	Pounds Plant Food Per Acre	SEC.-A-	SEC.-B-	SEC.-C-	SEC.-D-	AVE.
1	200 Nitrogen	41.4	43.2	39.6	46.2	42.6
2	200 Nit. - 4000 Mill Ash	51.7	47.3	44.3	46.6	47.5
3	200 Nitrogen	48.6	46.0	51.1	31.2	44.2
4	200 Nit. - 100 K_2O	48.8	45.7	53.3	37.6	46.3
5	200 Nitrogen	38.1	37.0	44.7	33.5	38.3
6	200 Nit. - 100 P_2O_5	34.7	39.0	40.3	38.7	38.2
7	200 Nitrogen	29.8	42.3	47.0	48.3	41.8
8	200 Nit. - 100 P_2O_5 - 4000 Mill Ash	36.1	35.6	56.8	60.0	47.1
9	200 Nitrogen	35.8	37.7	45.0	55.9	43.6
10	200 Nit. - 100 K_2O - 100 P_2O_5	29.0	44.7	50.6	40.6	41.2
11	200 Nitrogen	30.5	40.2	45.2	43.0	39.7
12	200 Nit. - 8000 Mill Ash	49.2	47.3	46.9	43.0	46.6
13	200 Nitrogen	33.4	40.9	35.8	40.6	37.7
14	200 Nit. - 200 K_2O	47.8	51.0	38.3	42.8	44.9
15	200 Nitrogen	29.7	36.2	36.7	41.6	36.0
16	200 Nit. - 200 P_2O_5	36.1	37.2	46.2	43.6	40.8
17	200 Nitrogen	34.1	32.4	47.6	30.8	36.2
18	200 Nit. - 200 P_2O_5 - 8000 Mill Ash	52.7	37.1	48.7	44.5	45.7
19	200 Nitrogen	23.5	38.9	41.9	40.0	36.1
20	200 Nit. - 200 K_2O - 200 P_2O_5	26.8	40.1	53.8	48.9	42.4
21	200 Nitrogen	17.6	46.5	39.1	41.6	36.2

A	B	C	D
Hilly and Level (plots 2–8)	Hilly and Level (plots 3–8)	High area (plots 2–5)	High area (plots 2–5)
Hilly and Low (plots 11–16)	Low area (plots 11–14)	Low area (plots 7–10)	Low area (plots 6–9)
High (plots 19–20)	High area (plots 17–20)	High area (plots 13–16)	Slope (plots 10–12)
		Low area (plots 18–21)	High area (plots 13–16)
			Low area (plots 18–21)

A B C D AVE.

Field Topography

Fig. 6. Showing the yield of cane per acre, of a fertilizer experiment, in relation to the field topography.

Fig. 7. Showing how the cane in a ''no nitrogen'' plot was affected by the nitrogen from the adjacent plot. Note the difference in growth, in the no nitrogen plot, of the cane in the two rows next to the check plot as compared with the third row. The difference in the color of the foliage was also very marked. Plot 7 received 186 pounds of nitrogen per acre, plot 8 had no fertilizer. The cane was ten months old D 1135 ratoons.

Fig. 8. Showing how the cane in a ''no phosphate'' plot was affected by the phosphate applied on the adjacent plot. Note the difference in growth, in the ''no phosphate'' plot, of the two rows of cane next to the 200-pound P_2O_5 plot as compared with the third, fourth and fifth rows. Both plots received equal amounts of nitrogen. The cane was twenty-four months old plant Uba.

Fig. 9. Showing how the cane in a check plot was affected by the potash applied on the adjacent plot. Note the difference in growth of the three rows of cane next to the 100-pound K_2O plot as compared with the fourth and fifth rows. Both plots received equal amounts of nitrogen. The cane was ten months old D 1135 ratoons.

Fig. 10. Showing how the cane in a check plot was affected by the phosphate and potash applied on the adjacent plot. Note the differerce in growth of the three rows of cane next to the 100-pound P_2O_5 and 100-pound K_2O plots as compared with the fourth and fifth rows. Both plots received equal amounts of nitrogen. The cane was ten months old D 1135 ratoons.

In Figs. 8, 9 and 10 the rows are four feet wide and the plots consist of eight rows each.

If such conditions as shown in Figs. 7, 8, 9 and 10 exist in fertilizer experiments under dry, unirrigated conditions, one wonders what happens to experiments which are subject to frequent irrigation and rainfall.

Observation: Observation in fertilizer tests, as a rule, is somewhat more elastic than that for variety tests. Much has been attained here at Honokaa by carefully examining fertilizer plots every three months, and by keeping notes in regard to the general appearance of one plot as compared with another, as well as the general appearance of the cane in each plot. A thorough examination of the plots at harvest also yields valuable information that is often not registered in the final figures. Growth measurements, borer and dead-cane counts, estimating the percentage of large- and small-size sticks and examining the root system all help in familiarizing one with the condition of the cane in the individual plots.

Harvesting: From the photographs in Figs. 7, 8, 9 and 10 it is obvious that the proper number of rows serving as guards on both sides of the plots should be omitted from the final results. The harvesting proceeds in the same manner as described under variety experiments. If the amount of plots is not too numerous, it is possible to take car-lot cane samples for juice analysis. If the number of plots prohibits this method, the next most satisfactory way is to take eight cane bundle samples from each plot.

Results: Bearing in mind that the experiment is to test fertilizer under general field conditions, the final results should be interpreted in that respect. This can best be illustrated from the data as shown in Fig. 6.

Taking the figures from plots 13, 14 and 15 in Fig. 6 as an example, it is noted that the treatment of 200 pounds of K_2O as compared with no potash gave, in Section A, 47.8 tons of cane per acre against 33.4 and 29.7 tons for the check plots. In Section B the same treatment gave 51.0 tons as compared with 40.9 and 36.2 tons for the check plots. In Section C the treated plot showed a tonnage of 38.3 against 35.8 and 36.7 for the checks, and in Section D 42.8 tons as compared with 40.6 and 41.6 tons for the checks. It is noted from the topography lines a, b, c and d that the two sections, A and B, giving the large gains in favor of the treatment, were in low-lying areas, while the other two, C and D, giving small gains, were on high areas.

It is further noted that the treated plot gave an average yield of 44.9 tons against 37.7 and 36.0 tons for the checks, or a gain of 8 tons of cane in favor of the treatment. The gains for Sections A, B, C and D were 16.3, 12.5, 2.1 and 1.7 tons, respectively. It is clearly seen from these figures that the general average does not reveal the true status of the results. The other plots may be compared in the same manner.

Fig. 6 shows the lay of the land crosswise of the plots only. As part of the detailed information in field tests, the topography of the areas is sketched lengthwise of the plots as well. With the proper lay of the land charted, one can compare to better advantage the juice qualities and sugar yields as well as the cane yields.

Bud Selection

WAIPIO SECTION 27

By J. A. Verret

Bud selection work was started here in 1920. For several years the work was under the supervision of A. D. Shamel, of the U. S. Department of Agriculture, stationed at Riverside, California, and engaged in citrus improvement by means of bud selection. Mr. Shamel made yearly visits of several months duration to the Islands for several years.

In 1927, all yield figures which had been obtained on the various H 109 progenies from the beginning of the bud selection work up to that time, were assembled and the progenies were graded according to their performance.

A test with as many repetitions as the available seed permitted was planned. Every other plot was planted with unselected H 109 seed. The area was laid out in carload-sized plots. Three progenies among the best and three among the progenies having made the poorest showing were included in this test. In addition, seven progenies were included which had been observed by W. W. G. Moir and others to be above or below the average of H 109 crop cane.

The progenies included in this test and their rating at the time are listed below:

P 172	10 plots	Good in previous tests
P 68	"	"
P 63	"	"
P 142	1 plot	Poor in previous tests
P 153	"	"
P 155	"	"
Dwarf 2456	10 plots	Said to be poor
Type 2	"	"
Type 1	"	Good in previous tests
Type 5	"	"
PM 204	3 plots	Selected by Mr. Moir as good
B 5 516	"	"
B 5 529	"	"

Progenies 172, 68, 63, 142, 153 and 155 were selected at Waipio in 1920. At the time of selection none of these were selected as poor types.

Types 1, 2, 5, PM 204, B5-516 and B5-529 were selected by Mr. Moir on Maui. Type 2 was considered poor at the time of selection. Dwarf 2456 was selected at Paauhau by the plantation authorities and was poor from the beginning, although it originated from a large stool of H 109.

The test was planted June 8-12, 1927, and harvested in April, 1929, at 22 months of age.

The results of the harvest are:

Progeny	Rating When Planted	No. of Plots	T. C. P. A.	T. S. P. A.	Per Cent Gain or Loss Over Check
172	Good	10	107.9	14.82	+ 7.2
Check		34	102.5	13.82	
68	Good	10	108.8	14.53	+ 4.2
Check		31	103.9	13.94	
63	Good	10	107.1	14.55	+ 3.8
Check		29	103.9	14.01	
Type 1	Good	10	104.7	14.20	+ 2.4
Check		31	103.0	13.86	
Type 5	Good	10	101.1	13.56	— .0
Check		28	99.5	13.58	
Type 2	Poor	10	104.1	13.83	+ 0.8
Check		28	101.2	13.71	
Dwarf 2456	Poor	10	100.0	13.47	— 3.2
Check		29	104.3	13.91	
PM 204*	Good	3	91.2	11.40	— 5.8
Check		8	95.9	12.06	
B5-516	Good	3	95.7	12.55	— 0.9
Check		7	96.7	12.66	
B5-529	Good	3	94.8	12.55	+ 2.4
Check		7	94.6	12.25	
P 142	Poor	1	103.6	13.39	— 0.3
Check		3	102.2	13.43	
P 153	Poor	1	93.8	11.95	— 0.9
Check		3	94.8	12.06	
P 155	Poor	1	87.8	10.75	—14.5
Check		3	94.9	12.57	

* One plot of PM 204 gave a yield of only 69 tons cane, much below any other plot in the test. Discarding that plot, the yields are: Cane 101.3 tons and sugar 13.1.

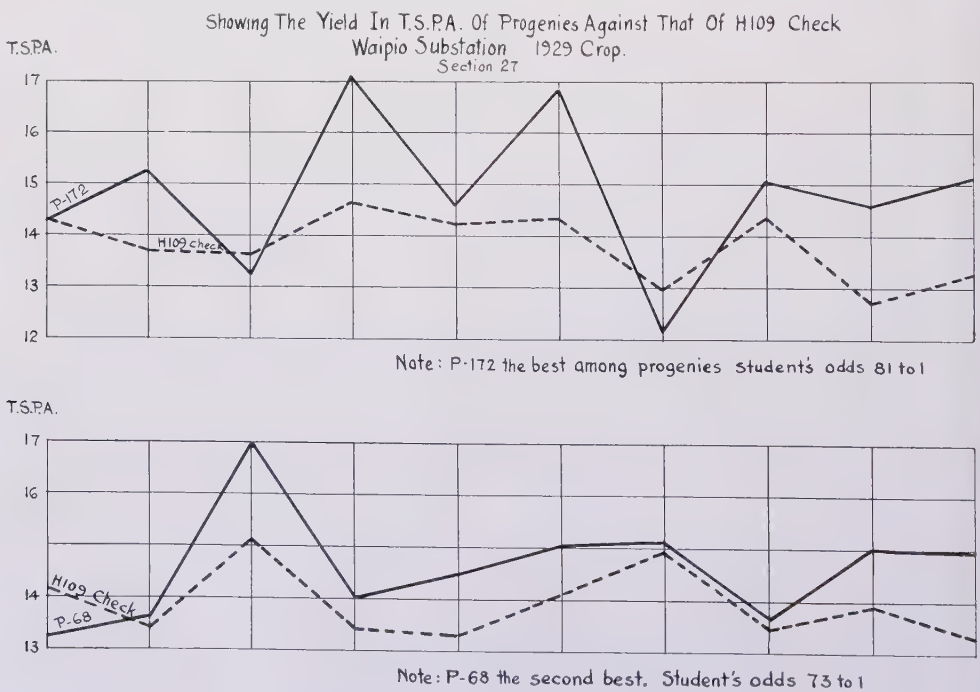

Fig. 1

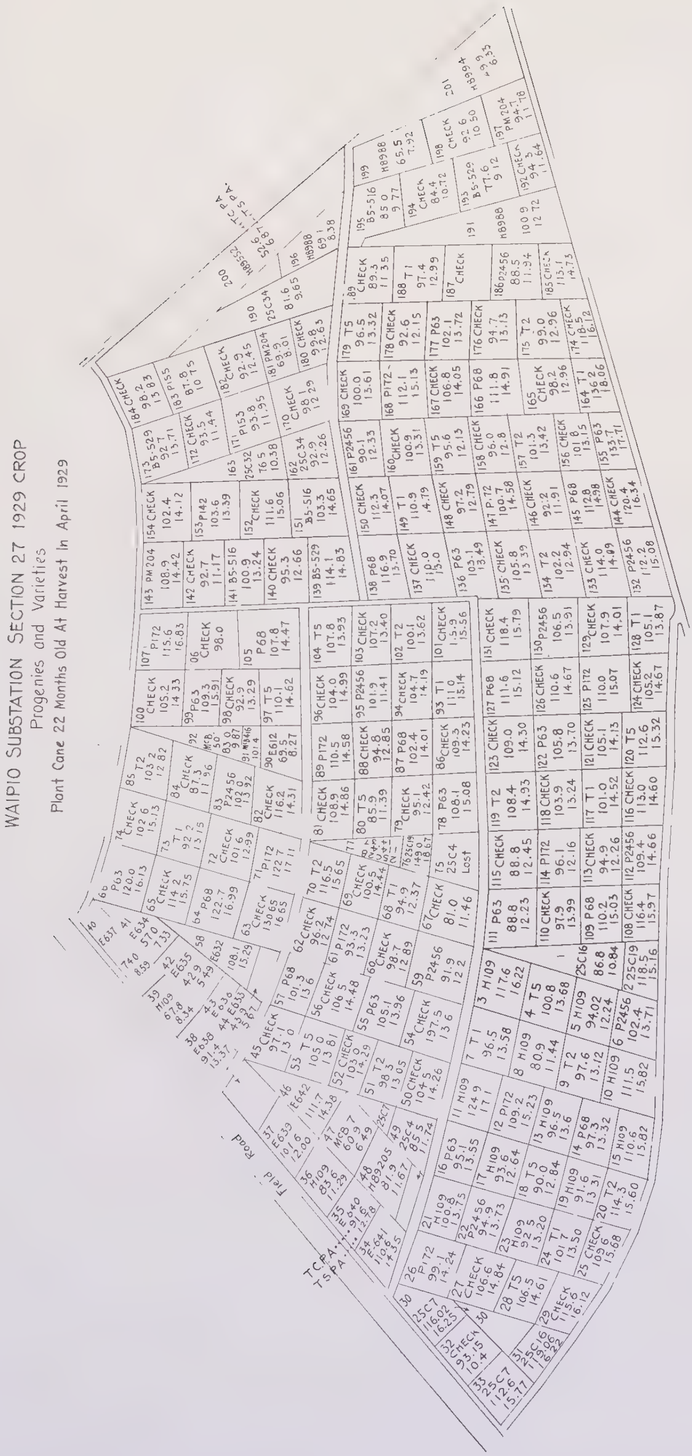
WAIPIO SUBSTATION SECTION 27 1929 CROP
Progenies and Varieties
Plant Cane 22 Months Old At Harvest In April 1929
Field Road

Fig. 2

Two of the progenies in the test are especially promising, having consistently outyielded H 109 in ten plot replications. These are Progeny 172 and Progeny 68. The plot yields of these two progenies with their unselected H 109 check plots are shown by means of graphs in Fig. 1.

A mathematical interpretation of these results by means of Student's Method gave odds of 81 to 1 that the gain of one ton of sugar of Progeny 172 over its checks was not due to chance. Progeny 68 was next with odds of 73 to 1. Progeny 63 also compared well.

Dwarf Progeny 2456, in accordance with its previous record, was poorer than its adjoining checks.

As a whole, these progenies behaved consistently with their previous records, indicating that the differences are inherent.

In Fig. 2 a map of the layout is shown with the yield of each plot.

Detailed Summary

Object: Bud selection and variety test.

Crop: H 109 and varieties, plant cane 22 months old.

Location: Waipio Substation Section 27.

Layout: Irregular size plots of about 6 lines each. Cane weights and juice samples taken at the mill of the Oahu Sugar Company.

Fertilization: Uniform to all plots.

August, 1927	October, 1927	February, 1928	Total N	Total P_2O_5	Total K_2O
951.7 CF	488 AS	617.7 AS	302	75	75

P-172

Plot No.	P 172 T.C.P.A.	P 172 T.S.P.A.	Plot Check Nos.	Check T.C.P.A.	Check T.S.P.A.	Gain of A Over B	d	d^2
26	99.13	14.24	27–21	103.7	14.30	— .06	+1.06	1.12
12	109.20	15.23	11–17–13–8	98.9	13.69	+1.54	— .54	.29
61	93.30	13.23	62–56–60–69	100.5	13.64	— .41	+1.41	1.99
71	122.7	17.11	63–72–82	116.1	14.65	+2.45	—1.45	2.10
89	110.5	14.58	81–96–88	102.6	14.23	+ .35	+ .65	.42
107	115.6	16.83	100–106	101.6	14.33	+2.50	—1.50	2.25
114	96.1	12.16	110–115–113–118	96.4	12.98	— .82	+1.82	3.31
125	110.0	15.07	121–129–126–124	107.2	14.37	+ .70	+ .30	.09
147	110.7	14.58	135–158–148–146	97.8	12.72	+1.86	— .86	.74
168	112.1	15.13	160–179–169–167	100.1	13.28	+1.85	— .85	.72
Avg.	107.9	14.82		102.5	13.82	9.96		13.03
					Mean	1.00		1.30

$$S.\ D. = \sqrt{1.30} = 1.14$$

$$Z = \frac{1.00}{1.14} = .9$$

Odds 81 to 1

P-68

Plot No.	P 68 T.C.P.A.	P 68 T.S.P.A.	Plot Check Nos.	Check T.C.P.A.	Check T.S.P.A.	Gain of A Over B	d	d^2
14	97.3	13.22	13–15–10–19	99.6	14.18	— .96	—1.65	2.72
57	101.3	13.60	45–56–52	99.93	13.41	+ .19	.50	.25
64	122.7	16.99	63–65–72	115.5	15.13	+1.86	+1.17	1.36
87	102.4	14.01	79–86–88–94	101.9	13.42	+ .59	— .1	— .01
105	107.8	14.47	98	92.8	13.29	+1.18	.49	.24
109	110.2	15.03	108–110–113	103.1	14.07	+ .96	.27	.07
127	111.6	15.12	125–126–131	112.7	14.92	+ .20	— .49	.24
138	116.9	13.70	137–150	111.1	13.53	+ .17	+ .52	.27
145	112.8	14.98	133–144–146–156	107.1	13.87	+1.10	.41	.17
166	111.8	14.91	158–165–167–176	98.9	13.26	+1.65	.96	.92
Avg.	108.8	14.53		103.9	13.94			
					Mean	+ .69		

S. D. = √ .625
= .78

$$Z = \frac{.69}{.78} = .885$$

Odds 73 to 1

P-63

Plot No.	P 63 T.C.P.A.	P 63 T.S.P.A.	Plot Check Nos.	Check T.C.P.A.	Check T.S.P.A.	Gain of A Over B	d	d^2
16	95.11	13.55	11–17–21	106.4	14.50	— .95	+1.49	2.22
55	105.1	13.96	60–56–52–54–65–74	101.4	13.81	+ .15	+ .39	.15
66	120.0	16.13		108.4	15.44	+ .69	— .15	.03
78	108.1	15.08	86–79	102.2	13.32	+1.76	—1.22	1.49
99	109.3	15.91	98–106–100	98.7	13.86	+2.05	—1.51	2.28
111	88.8	12.23	110–115–3	101.4	14.19	—1.86	+2.40	5.76
122	105.8	13.70	123–126–121–118	107.1	14.08	— .38	+ .92	.85
136	103.1	13.49	135–137–148–144–156	104.7	13.06	+ .43	+ .11	.01
155	133.7	17.71		111.1	14.75	+2.94	—2.40	5.76
177	102.1	13.72	167–178–176	98.0	13.11	+ .61	— .07	.05
Avg.	107.1	14.55		103.9	14.01	+5.44		18.60
					Mean	+ .54		1.86

S. D. = √1.86
= 1.36

$$Z = \frac{.54}{1.36} = .29$$

Odds 4.11 to 1

T 1

Plot No.	T 1 T.C.P.A.	T.S.P.A.	Plot Check Nos.	Check T.C.P.A.	T.S.P.A.	Gain of A Over B	d	d^2
7	96.5	13.58	3–8–11	107.8	14.93	—1.35	—1.69	2.86
24	101.7	13.50	19–23–25–29	102.4	14.58	—1.08	—1.42	2.01
68	94.9	12.37	60–67–69	93.4	12.93	— .65	— .90	.81
73	92.2	13.15	65–72–74–84	101.4	13.98	— .83	—1.16	1.37
93	111.0	15.14	84–94–101	109.9	14.66	+ .48	.14	.02
188	94.4	12.99	178–189	90.9	11.75	+1.24	.90	.81
149	110.9	14.79	137–148–150–160	105.1	13.29	+1.50	1.16	1.35
164	136.2	18.06	165–174	108.3	14.54	+3.52	3.18	10.11
117	101.0	14.52	118–116–113–121	104.2	13.56	+ .96	.62	.38
128	105.1	13.87	124–129	106.5	14.34	— .47	— .81	.66
Avg.	104.7	14.20		103.0	13.86	+3.41		20.38
					Mean	.34		2.04
							S. D. =	$\sqrt{2.04}$
							=	1.43

$$Z = \frac{.34}{1.43} = .24$$

Odds 3.1 to 1

T 2

Plot No.	T 2 T.C.P.A.	T.S.P.A.	Plot Check Nos.	Check T.C.P.A.	T.S.P.A.	Gain of A Over B	d	d^2
9	96.60	13.12	8–5–10–13	95.8	13.28	— .16	0.27	.0729
20	114.32	15.60	25–15–19	103.9	14.94	.66	— .55	.3025
51	98.3	13.05	50–52	103.8	14.25	—1.23	1.34	1.7956
70	116.5	15.85	62–69	98.9	13.59	2.26	—2.15	4.6225
85	103.2	12.82	74–84	94.9	13.55	— .73	.84	.7056
102	100.1	13.62	94–101–103	109.2	14.38	— .76	.87	.7569
157	101.3	13.42	146–156–158	95.0	12.62	.80	— .69	.4761
175	99.0	12.96	165–174–176	105.7	14.07	—1.11	1.22	1.4884
119	108.4	14.93	115–118–123	100.6	13.33	1.60	—1.49	2.2201
134	102.2	12.94	133–135–146	104.0	13.13	— .19	.30	.09
Avg.	104.1	13.83		101.2	13.71	1.14		12.6305
					Mean	.11		1.26
							S. D. =	$\sqrt{1.26}$
							=	1.12

$$Z = \frac{.11}{1.12} = .098$$

Odds 1.59 to 1

T 5

Plot No.	T 5 T.C.P.A.	T.S.P.A.	Plot Check Nos.	Check T.C.P.A.	T.S.P.A.	Gain of A Over B	d	d^2
4	100.8	13.68	3–5–8	97.5	12.66	—1.02	+1.03	1.06
18	90.0	12.84	17–13–19–23	93.6	13.19	+ .35	— .34	.12
28	106.50	14.61	23–29–27	104.9	14.72	+ .11	— .10	.01
53	105.0	13.91	56–45–52	102.2	13.92	+ .01	.....	....
97	110.1	14.62	98	92.9	13.29	—1.33	+1.34	1.80
104	107.8	13.93	96–103	105.6	14.20	+ .27	— .26	.07
179	96.5	13.22	169–189–178	93.9	12.37	— .85	+ .86	.74
159	95.6	12.13	148–167–160–158	100.2	13.24	+1.11	—1.10	1.21
120	112.6	15.32	116–121–113	104.3	14.43	— .89	+ .90	.81
80	85.9	11.39	81–88–79	99.6	13.75	+2.36	—2.35	5.52
Avg.	101.1	13.56		99.5	13.58	.12		11.34
					Mean	.01		1.13

$$S.\ D. = \sqrt{1.13} = 1.06$$

$$Z = \frac{.01}{1.06} = .008$$

No odds

P-2456

Plot No.	P 2456 T.C.P.A.	T.S.P.A.	Plot Check Nos.	Check T.C.P.A.	T.S.P.A.	Gain of A Over B	d	d^2
6	102.40	13.71	5–10	102.7	14.03	+ .32	.12	.01
22	94.9	13.73	17–21–23–27	98.36	13.60	— .13	.15	.02
59	91.90	12.20	54–60–67	92.4	12.65	+ .45	— .01	....
83	102.0	13.92	72–82–84	101.7	13.09	— .83	1.27	1.61
95	101.9	11.41	88–103–94–96	102.7	13.86	+2.45	—2.01	4.04
112	109.4	14.66	113–116–108	108.0	14.27	— .39	.83	.69
130	106.5	15.79	126–129–131	112.3	14.82	— .97	1.41	1.99
132	112.2	15.00	144–133	117.0	15.22	+ .22	.22	.05
161	90.1	12.33	150–160–169	104.4	13.66	+1.33	— .89	.79
186	88.5	11.94	176–185	103.9	13.93	+1.99	— .55	2.40
Avg.	100.0	13.47		104.3	13.91	+4.44		11.60
					Mean	.44		1.16

$$S.\ D. = \sqrt{1.16} = 1.07$$

$$Z = \frac{.44}{1.07} = .41$$

Odds 6.67 to 1 in favor of check

PROGENIES PM 204, B5-516, B5-529, P 142, P 153 AND P 155

Progeny	Plot No.	T.C.P.A.	T.S.P.A.	Check Plot Nos.	T.C.P.A.	T.S.P.A.
PM 204	143	108.9	14.42	154–142	97.5	12.64
PM 204	181	69.9	8.01	182–170–180	96.9	12.46
PM 204	197	94.7	11.78	192–198	93.4	11.07
B5-516	141	100.0	13.24	142–140–153	99.9	12.96
B5-516	151	103.3	14.65	140–152	103.4	13.86
B5-516	195	85.0	9.77	189–194	86.8	11.03
B5-529	139	114.1	14.83	140	95.3	12.66
B5-529	173	92.7	13.71	172–184–154	98.0	13.13
B5-529	193	77.6	9.12	194–198–193	90.4	10.95
P 142	153	103.6	13.39	154–142–152	102.2	13.45
P 153	171	93.8	11.95	172–182–170	94.8	12.06
P 153	183	87.8	10.75	184–172–182	94.9	12.57

The Mitscherlich Method of Soil Testing and Interpretation of Results

By W. J. Hartung

Introduction

The name of Mitscherlich is invariably associated with The Law of Diminishing Returns. As a matter of fact, to those working in the realm of soil and plants, the contribution of vital interest made by Mitscherlich is soil testing by physiological means. It is a quantitative soil analysis, just as is a well-planned, carefully conducted field experiment, with the plant as analyst.

Journals and periodicals, scientific and otherwise, in the English language, contain many references to Mitscherlich, which deal with his "Wirkungsgesetz der Wachstumsfactoren"; few however, have taken the trouble to pry into the long years of painstaking labor. Countless experiments carefully carried out, furnish the foundation for the promulgation of the law stated above.

It is with the idea of bringing to the attention of investigators of soil and plants the methods pursued by Mitscherlich in his determination of the fertilizer requirement of the soil and the interpretation of these pot experiment results in terms of field practice that this brief article has been prepared.

Taking of Soil Sample

After the crop has been harvested and a knowledge of soil requirement for succeeding crops is desired, proceed with sampling as follows:

Drive across the field at about 75 to 80 feet from the border and parallel thereto, using a vehicle with well cleaned body or bed. Toss into this truck or wagon bed at 150-foot intervals a spade full of soil, penetrating surface soil to a depth of about 5 to 6 inches. Arrived at the end of the field, return, keeping parallel to the original course and at a distance of about 150 feet therefrom. Continue this procedure until the whole field has been sampled.

A total of 150 to 200 individual samples should have been taken, depending of course upon the size of the area samples. (*Caution:* Samples should not be taken when soil is wet to stickiness.) The soil is screened through an ordinary gravel screen, and after several thorough mixings by use of shovels, approximately 250 pounds are placed in clean sacks (avoid fertilizer sacks). If soil is too wet for shipment it should be permitted to air dry, care being taken that drying is natural, and that no dog or animal excrements be deposited thereon or in. After soil has been placed in sacks it is ready for shipment to the experimental laboratory.

Installation of the Pot Experiment

Twenty Mitscherlich enameled pots, well cleaned, of a size suitable for cereals, are brought to the same tare by introduction of pieces of quartz rock. Thus all pots, exclusive of soil, weigh exactly alike. The soil is screened through a 1 cm.

sieve and again well mixed by shovel. A sample of soil is taken for soil moisture determinations. The soil should have a moisture content equivalent to that present when soil is in its best physical and mechanical state, neither too wet nor too dry. Each of eight of the prepared pots is now ready to receive its portion of soil. Four of the pots receive soil plus a complete fertilizer. Each portion of soil is carefully weighed out (6 kg.). This is placed in a large mixing pan and in this particular test, for example, the following quantities of fertilizing ingredients were added thus per pot (4 replications):

6 KG OF SOIL

P_2O_5—6 gm. of Thomas Slag........................	19.4	dz/ha
K_2O—3 gm. of Potash Sulphate.....................	9.7	dz/ha
N—5 gm. of Ammonium Sulphate....................	16.25	dz/ha

NOTE.—Equivalent in nitrogen in the form of ammonium nitrate or urea may be used.

Each batch is thoroughly mixed by hand in the mixing dish provided. The well mixed soil is transferred to the tared pot, care being taken that the first layer of about 5 cm. in thickness is firmly pressed against the bottom, thereby filling the holes, thus allowing no soil to fall through; furthermore, the remaining soil must be filled in rather loosely yet packed so that soil surface is about 2 cm. below the level of the upper edge of the pot. *Caution:* Be sure to wash mixing dish and hands thoroughly between potting differently treated soils as the fertilizer adhering will affect results of the subsequent potting.

Liming of soil is not necessary if the water used for irrigation contains .03 gram of calcium per liter. On the other hand, .5 gram of sodium chloride is added to each pot to insure the highest action from potash. All constituents added must be carefully weighed, accuracy to 1 per cent being desired. Water soluble ingredients are best added in solution, when upon mixing by hand with some additional water a very satisfactory product results. The pot on being filled is numbered and set aside. Failure to properly number and otherwise designate each container promptly, distinctly and permanently, often leads to experimental errors which can not be rectified subsequently. The exact weight of each pot is then determined. The four other pots also receive equal quantities of soil and fertilizer with exception of nitrogen, none being added.

The remaining pots provide three groups of four pots each, each group to receive but one-sixth the amount of soil employed in groups 1 and 2. Thus a pot will contain 1 kg. of the soil under test and 5 kg. of clean sand, quartz preferably, the available potash and phosphoric acid of which is already known or is to be determined concurrently. Thus the four pots, group 3, will contain 1 kg. of soil, 5 kg. sand and a complete fertilizer of exactly the same composition as that added to soil in group 1.

The four pots of group 4 will receive the same mixture as group 3 minus, however, the potash salt, and the four pots constituting group 5 will each contain the same mixture of soil, sand and fertilizing ingredients as group 3 minus the phosphoric acid constituent.

Following the same procedure and observing the same caution given above, the different portions are mixed, and after placing a piece of gauze over the bot-

tom of the pots to prevent the sand from passing through the holes, each pot is filled and notations are made in a manner as stated above. These twenty pots are quite sufficient for a determination of the supplies of the three chief plant nutrients in a soil. *Note:* Mitscherlich advises that fertilizers of neutral reaction be utilized.

The pots are now ready for planting. A circular board of a diameter a trifle less than the inside diameter of the pot, fitted with twenty-five short pegs—.5 cm. in diameter and 1.5 cm. in length and spaced 3 cm. x 3 cm.—is pressed, pegs downward, into the soil and carefully withdrawn leaving twenty-five holes uniform in every respect. Oats of same strain, from the same field, and preferably from the same harvest should be employed. The oat plant is used as the indicator because it requires relatively little space for growth, because it has a short growing period from seed to maturity, because there is certainty as to yield and heavy yield at that, and because it is but little subject to diseases. Two seeds are placed in each small hole and loosely covered with soil. At the end of fourteen days all seeds should have sprouted, whereupon the stands are thinned down to thirty-five plants per pot.

Setting the pots so that the factors light and heat may be uniform to all is a difficult matter. There has been a contrivance constructed which rests on a small truck. It consists of a standard upright in the center of the truck to which are attached four arms, each capable of holding one pot. This arrangement permits of moving the pots about so that all may have an equal amount of light and warmth.

The matter presenting the greatest of difficulties is that of regulation of soil moisture. The supply of soil water must be kept constant. As long as plants are small and little difference exists between the different pots a constant moisture content may be maintained through regular weighings. Since all pots have the same weight as to tare and all have equal weights of soil, the water content of each may be arrived at through calculation, the soil moisture having been determined on potting.

While the seeds are still sprouting, a light sprinkling will suffice. However, as soon as the plants begin to draw on the soil water, it becomes imperative that the moisture content of all pots be brought to a constant. This may be accomplished as follows: Immediately on removal of excess of plants, the pot is placed on a scale and an amount of water is added which is equal to 50 per cent of the quantity of water the soil is capable of retaining at, viz., its water-holding capacity. Thus the gross weight of the pot equals tare + soil weighed in + 50 per cent of the water required to bring the particular soil to its maximum water-holding capacity. For a time, at weekly intervals, the pots are weighed and water added. Very soon this work must be done every other day, then daily, adding 15 per cent of the water-holding capacity so that at the time the grain is ready to head out, full water-holding capacity has been attained. It is now imperative that this moisture content be maintained. Since the plants in some of the pots are now larger and quite considerably heavier than those of other pots, constant uniform water content cannot be regulated through weighings. The scale is set aside and water is added until it runs out through the bottom. This water is easily returned to the pot since it is caught in the tray fitted to the bottom, thus none of the fertilizing ingredients are lost. This manner of application of water is continued

until within a short time before the date of harvest, when less and less water is required, in fact during the last week very little water need be added, possibly none.

To shield the growing oats from wind damage, wire frames so constructed as to hold the stalks close together are attached to each pot at about the time the grain is ready to head. The harvest from each pot must be removed with the greatest of care. The grain is first carefully stripped from the stalk while stalks and roots are still intact. It is placed in a flask and labeled to correspond with the pot number. The stalks are then cut close to the soil by means of shears, and both grain and straw are dried at 100° C., weighed and yields recorded in grams. These results are later converted to units of weight per hectare; thus, double zentner (dz.) per hectare (ha.). 1 dz. — 100 kg. or 220.4 lbs; 1 ha. — 10,000 sq. meters or 2.471 acres. To avoid confusion in this discussion, we shall throughout use the (dz.) as the unit of weight, and the (ha.) as the unit of area. Let it now be assumed that the results secured from our oat test are as follows:

	Grain and Straw
Average of 4 pots group 1—Soil + N, K, and P (N as Ammonium Sulphate, amount 5 grams)	125.8 ± 1.1 gm.
Average of 4 pots group 2—Soil + K and P	20.4 ± 0.6 gm.
Average of 4 pots group 3—1/6 Soil + 5/6 Sand + N, K and P	113.0 ± 1.5 gm.
Average of 4 pots group 4—1/6 Soil + 5/6 Sand + N and P	90.7 ± 1.2 gm.
Average of 4 pots group 5—1/6 Soil + 5/6 Sand + N and K	66.0 ± 0.8 gm.

Converting yields of groups 1 and 2 to dz ha we arrive at these values:

	Grain and Straw
Group 1—Soil + N, K and P (16.25 dz/ha Sulphate of Ammonia)	408.9 ± 3.6 dz/ha
Group 2—Soil + K and P	66.3 ± 2.0 dz/ha

The yields resulting from complete fertilization are enormous, in fact Mitscherlich is quite agreed that they are unattainable under field conditions, whereas the yield from the same soil with nitrogen eliminated is so very much less, that the difference between the two yields is decidedly not anywhere near the differences which may be encountered under field conditions. It is just these particularly wide differences which provide the means for a more accurate determination of plant food requirement by pot method over the field. Thus the probable error in pot work when dealing with yields will indicate significant differences, whereas yields from similarly treated plots under field conditions differ so slightly that the probable error reveals nothing tangible.

Calculation

Having converted the yields—variable nitrogen—to units in area and weight, the first step is to find the "Höchstertrag A" as Mitscherlich prefers to designate the highest yield attainable. The formula for this purpose arrived at through experimental means and higher mathematics is finally reduced to the expression $A = \frac{Ky - y^o}{K - 1}$ where K is the antilog of c times x; c being the action factor

(Wirkungswert) of ammonium sulphate which has been established experimentally at .025, and x being the unit application of ammonium sulphate, in this case (16.25 dz/ha); y is the yield secured on application of the unit (16.25 dz/ha) of ammonium sulphate; and y^o is the yield secured when nitrogen is omitted from the fertilization. Substituting

$$A = \frac{(2.549 \times 408.9) - 66.3}{1.549} \text{ or } 629.9 \text{ dz/ha the highest yield attainable.}$$

Then $(66.3 \times 100) \div 629.9 = 10.5$ the per cent yield of the highest yield attainable when no nitrogen has been added to the natural supply. Thus the soil under test is limited to a yield 10.5 per cent of the very highest yield attainable due to the limiting factor nitrogen. Now what does this imply in the soil? Let us see how we may arrive at the amount of available nitrogen present in terms of ammonium sulphate.

$$b = \frac{\log A - \log (A - y^o)}{c}$$

will give us the amount of available nitrogen (b) present in terms of ammonium sulphate: substituting

$$b = \frac{2.7993 - 2.7510}{.025} \text{ or } 1.93 \text{ dz/ha}$$

Thus the amount of sulphate of ammonia in one hectare of surface soil to a depth of 14 cm. is in this instance but 1.93 double zentner, and is responsible for a 10.5 per cent "A" yield. This step completes the analysis of the particular soil as regards available nitrogen in terms of ammonium sulphate, the calculation may then be carried further and results secured as the element nitrogen.

Potash and phosphoric acid, the other two fertilizer constituents, may be arrived at without converting the pot yields to field basis at the outset. There has been added to the pots sufficient of each of these ingredients to result in the "Höchstertrag A". Thus $(90.7 \times 100) \div 113 = 80.3$, the per cent yield of the highest yield attainable with no additional potash. This is equivalent to 1.86 dz/ha of a potash salt containing 40 per cent K_2O, the action factor or (Wirkungswert), of which is .38 in the presence of sodium. The figure of 1.86 dz/ha is arrived at through substitution in formula:

$$b = \frac{\log A - \log (A - y^o)}{c}$$

There being but 1/6 soil in each pot and 5/6 sand, correction must be made for same. The sand previously determined contains available potash to the extent of .44 dz/ha, deducting this from 1.86 leaves but 1.42 dz/ha of a 40 per cent K_2O potash salt in 1/6 of the quantity of surface soil, therefore, 1.42×6 or 8.52 double zentner is the quantity of a 40 per cent potash salt present in 1 hectare of surface soil 14 cm. in thickness.

The available phosphoric acid content of the soil is arrived at in the same manner—thus $(66 \times 100) \div 113 = 58.4$, the per cent yield of the highest yield attainable. Substituting and solving for (b) we find that the soil contains 3.81 dz/ha of phosphoric acid expressed as Thomas slag having an action value (Wirkungswert) of 0.1. Correcting for the phosphoric acid found in the 5 kg.

of sand equivalent in terms of Thomas slag to 1.00 dz/ha, leaves 2.81 dz/ha remaining in the 1/6 soil portion, multiplying by 6 results in 16.86 dz., which is the quantity of Thomas slag of 16.3 per cent P_2O_5 content present in 1 hectare of surface soil 14 cm. in thickness.

We have now the desired information, viz., the quantities of the three chief plant food elements present in the soil and available to the plant in terms of fertilizer constituents. The plant has indicated quantitatively by its response the available plant food in the particular soil under investigation. It is unnecessary to follow the process for a determination of (b) through formula, for Mitscherlich has computed all these values and arranged them in tabular form. Thus all that is required in the way of calculation is the determination of the per cent yield of the highest yield attainable. Given this figure, which in the case of nitrogen in this example, proves to be 10.5 per cent, we locate same in the column headed Sulphate of Ammonia and by interpolating, find under heading "Present in Soil dz/ha" the amount of the fertilizer constituent as between 1.9 and 2.0 dz/ha, as near as possible to the figure arrived at through calculation, viz., 1.93.

TABLE I

Table of Yield for the Chief Plant Food Constituents and for a Typical Fertilizer Material of Each

Present in Soil dz/ha	Yields Per Cent of Highest Yields Attainable						
	Potash K_2O	40 Per Cent Potash Salt	Potash K_2O Without Sodium	Phosphoric Acid P_2O_5	Thomas Slag 16.3 Per Cent P_2O_5	Nitrogen (N)	Sulphate Ammonia 20.5 Per Cent N
	In Presence of Sodium						
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	19.3	8.4	7.3	12.9	2.3	2.8	0.6
0.2	34.8	16.0	14.1	24.1	4.5	5.5	1.1
0.3	47.4	23.1	20.4	33.9	6.7	8.1	1.7
0.4	57.5	29.5	26.2	42.5	8.8	10.6	2.3
0.5	65.7	35.4	31.6	49.9	10.9	13.1	2.8
0.6	72.3	40.8	36.6	56.3	12.9	15.5	3.4
0.7	77.7	45.8	41.2	62.0	14.9	17.8	3.9
0.8	82.0	50.3	45.4	66.9	16.8	20.1	4.5
0.9	85.4	54.5	49.5	71.2	18.7	22.3	5.0
1.0	88.2	58.3	53.2	74.9	20.6	24.5	5.6
1.1	90.5	61.8	56.6	78.1	22.4	26.6	6.1
1.2	92.3	65.0	58.8	80.9	24.1	28.6	6.7
1.3	93.8	68.0	62.8	83.4	25.9	30.6	7.2
1.4	95.0	70.6	65.5	85.5	27.6	32.5	7.7
1.5	96.0	73.1	68.0	87.4	29.2	34.4	8.3
1.6	96.7	75.3	70.3	89.0	30.8	36.2	8.8
1.7	97.4	77.4	72.5	90.4	32.4	38.0	9.3
1.8	97.9	79.3	74.5	91.7	33.9	39.7	9.8
1.9	98.3	81.0	76.4	92.8	35.4	41.4	10.4
2.0	98.6	82.6	78.1	93.7	36.9	43.0	10.9
2.1	98.9	84.1	79.7	94.5	38.3	44.6	11.4
2.2	99.1	85.4	81.2	95.2	39.7	46.1	11.9
2.3	99.3	86.6	82.6	95.8	41.1	47.6	12.4
2.4	99.4	87.7	83.9	96.4	42.5	49.0	12.9
2.5	99.5	88.8	85.0	96.8	43.8	50.4	13.4

Present in Soil dz/ha	Potash K_2O In Presence of Sodium	40 Per Cent Potash Salt In Presence of Sodium	Potash K_2O Without Sodium	Phosphoric Acid P_2O_5	Thomas Slag 16.3 Per Cent P_2O_5	Nitrogen (N)	Sulphate Ammonia 20.5 Per Cent N
2.6	99.6	89.8	86.1	97.2	45.0	51.8	13.9
2.7	99.7	90.6	87.1	97.6	46.3	53.2	14.4
2.8	99.8	91.4	88.1	97.9	47.5	54.5	14.9
2.9	99.8	92.1	89.0	98.2	48.7	55.7	15.4
3.0	99.8	92.8	89.8	98.4	49.9	56.9	15.9
3.2	99.9	93.9	91.4	98.8	52.1	59.3	16.8
3.4	99.9	94.9	92.6	99.1	54.3	61.5	17.8
3.6	100.0	95.7	93.7	99.3	56.3	63.6	18.7
3.8	100.0	96.4	94.6	99.5	58.3	65.6	19.6
4.0	100.0	97.0	95.3	99.6	60.2	67.5	20.6
4.2	100.0	97.5	96.0	99.7	62.0	69.3	21.5
4.4	100.0	97.9	96.5	99.8	63.7	70.9	22.4
4.6	100.0	98.2	97.0	99.8	65.3	72.5	23.3
4.8	100.0	98.5	97.5	99.9	66.9	74.0	24.1
5.0	100.0	98.7	97.8	99.9	68.4	75.4	25.0
5.5	100.0	99.2	98.5	99.9	71.8	78.7	27.2
6.0	100.0	99.5	99.0	100.0	74.9	81.5	29.2
6.5	100.0	99.7	99.3	100.0	77.6	83.9	31.2
7.0	100.0	99.8	99.5	100.0	80.0	86.0	33.2
7.5	100.0	99.8	99.6	100.0	82.2	87.8	35.1
8.0	100.0	99.9	99.7	100.0	84.1	89.4	36.9
8.5	100.0	99.9	99.8	100.0	85.5	90.8	38.7
9.0	100.0	100.0	99.9	100.0	87.5	92.0	40.4
9.5	100.0	100.0	100.0	100.0	88.8	93.1	42.1
10.0					90.0	94.0	43.8
10.5					91.1	94.8	45.4
11.0					92.1	95.4	46.9
11.5					92.9	96.0	48.4
12.0					93.7	96.6	49.9
12.5					94.4	97.0	51.3
13.0					95.0	97.4	52.7
13.5					95.5	97.7	54.0
14.0					96.0	98.0	55.3
14.5					96.4	98.3	56.6
15.0					96.8	98.5	57.8
16.0					97.5	98.9	60.2
17.0					98.0	99.2	62.4
18.0					98.4	99.4	64.5
19.0					98.7	99.5	66.5
20.0					99.0	99.6	68.4
21.0					99.2	99.7	70.2
22.0					99.4	99.8	71.8
23.0					99.5	99.8	73.4
24.0					99.6	99.9	74.9
25.0					99.7	99.9	76.3
26.0					99.7	99.9	77.6
28.0					99.8	100.0	80.1
30.0					99.9	100.0	82.2
35.0					100.0	100.0	86.7
50.0					100.0	100.0	94.4
75.0					100.0	100.0	98.7
100.0					100.0	100.0	100.0

Interpretation of Results and Applicattion of Same to Practice

Following through with the example as carried forward. In the surface stratum of soil, 1 hectare in area of a 14 cm. thickness there is available nitrogen equivalent to 1.93 dz/ha of sulphate of ammonia, available potash equivalent to 8.52 dz/ha of a 40 per cent potash salt and available phosphoric acid equivalent to 16.86 dz/ha of a 16.3 per cent Thomas slag. Since the root mass of most all field crop plants is not confined to the shallow surface layer represented by the 14 cm. thickness, but occupies the substratum as well, Mitscherlich dealing as he does with general field crops makes provision by multiplying the above quantities each by 2. This provides for a soil layer 28 cm. or 11 inches and fairly well covers the feeding zone of most farm crops. Mitscherlich admits that this arbitrary manner of providing for subsoil plant food content is the weakest point in the whole procedure, but feels justified in taking this course since the method provides for a very accurate determination of the actual available plant nutrients in a definite layer of certain thickness, which is decidedly more exact and to the point than may be revealed by a chemical analysis of 100 grams of the soil. For more details on defense of his manner of dealing with results, see *Die Bestimmung des Düngerbedürfnisses des Bodens,* pages 57 to 60 inclusive. With the plant food in the soil stratum occupied by the root mass now double, we find on consulting Table I that the per cent yield of the highest yield attainable (A), for each fertilizer constituent has likewise changed. Thus with a sulphate of ammonia content of 2×1.93 or 3.86 dz/ha present in soil, we find that a 20 per cent yield is the highest possible; $2 \times 8.52 = 17.04$ dz/ha potash salt resulting in a yield (A). Since all that is required is 7.5 dz/ha of a 40 per cent potash salt, there is left in reserve a balance of 9.5 dz/ha. As to phosphoric acid, $2 \times 16.86 = 33.72$ dz/ha Thomas slag resulting in yield (A), see Table I, leaving 3.7 dz/ha in reserve. The soil is particularly deficient in nitrogen and although there is more than sufficient potash and phosphoric acid for a 100 per cent "A" yield, yet a 20 per cent crop only may be grown unless the nitrogen content is raised.

The discussion has been limited to the indicator crop oats. The next step is to apply the findings to any cultivated crop which has its feeding area within the zone designated, viz., a soil stratum 28 cm. in thickness. Below find in Tables II and III, application of the principles covering a rotation in general field crops:

TABLE II

Example of a 6-Year Crop Rotation

Crop		Yield dz/ha	Plant Foods in dz/ha Removed Nitrogen (N)	Potash K_2O	Phosphoric Acid P_2O_5
1 Potatoes	Tubers	200	0.64	1.20	0.28
	Tops	60	0.18	0.51	0.10
2 Rye	Grain	20	0.28	0.12	0.17
	Straw	50	0.23	0.50	0.13
3 Oats nurse crop for clover	Grain	25	0.45	0.13	0.21
	Straw	50	0.33	0.80	0.18
4 Red Clover	Hay	50	(0.99)	0.75	0.28
5 Rye	Grain	22	0.31	0.13	0.19
	Straw	55	0.25	0.55	0.14
6 Oats	Grain	25	0.45	0.13	0.21
	Straw	50	0.33	0.80	0.18
Totals removed			3.45	5.62	2.07
Returned to (1) 300 dz/ha and to (5) 150 dz/ha a total of 450 dz/ha of barnyard manure			0.90	2.00	0.00
Balance to be replaced by fertilizers			2.55	3.62	2.07

which implies in terms of ammonium sulphate 13 dz/ha; of a 40 per cent potash salt 9 dz/ha; and of a 16.3 per cent Thomas slag 12 dz/ha.

On computation and reference to Table I, it will be noted that nitrogen in some form must be added quite generously to bring up the yields of all crops that may be grown, assuming that the field on which the above rotation is to be followed has been found to contain the quantities of plant food indicated by our experimental oat crop grown in pots.

The potato crop may be heavily fertilized with nitrogen without danger, but cereals will allow of limited amounts only or lodging will follow, or possibly, even root damage. This does not permit of a building up of the nitrogen reserve quickly, and legumes should be seeded in the grain crops providing a green manuring which makes growth after the cereal crops have been harvested. This manner of management will add both nitrogen and organic matter and if to each cereal crop sufficient nitrogen from commercial fertilizers be added to provide for what is removed by the crop plus a small excess and to each root crop a generous supply, well exceeding the quantity removed, it will not be a difficult matter to maintain the fertility at a point so that a yield 50 per cent of the highest yield attainable may be expected, provided the potash and phosphoric acid contents are not allowed to fall below the amounts required to produce the "A" yield.

Suppose the aim is to maintain a 50 per cent "A" yield, for example a 50 per cent potato crop and a 50 per cent oat yield, etc., throughout this cycle, bearing in mind the important matter of excess nitrogen when dealing with cereals, yet leaving the soil at the end of the sixth year capable of producing, on reasonable fertilization, a 50 per cent "A" yield. By following the scheme as laid out in Table III, we should attain this objective.

TABLE III

Balance Sheet

Elements Found Present in Quantities Sufficient to Produce a 20 Per Cent "A" Yield at Beginning of Rotation Scheme, Table II

Nitrogen	.77 dz/ha
Potash	6.82 dz/ha
Phosphoric Acid	5.50 dz/ha

PLANT FOOD ELEMENTS IN DZ/HA

Crop	Added to Soil			Removed by Crop		
	Nitrogen N	Potash K_2O	Phosphoric Acid P_2O_5	Nitrogen N	Potash K_2O	Phosphoric Acid P_2O_5
1st year—Potatoes	1.20	1.33	none	.72	1.71	.38
2nd year—Rye and Green Manure	.92	none	none	.51	.62	.30
3rd year—Oats	.61	none	none	.88	.93	.39
4th year—Clover	.99	none	none	.99	.75	.28
5th year—Rye and Green Manure	1.00	none	none	.56	.68	.36
6th year—Oats	.64	.67	none	.78	.93	.39
Totals	4.37	2.00	0.0	3.45	5.62	2.10
Present at outset	.77	6.82	5.50	——	——	——
Total present and added	5.14	8.82	5.50			
Total removed	3.45	5.62	2.10			
Remaining at beginning of seventh year	1.69	3.20	3.40			
Required to produce 50 per cent "A" yield of potatoes	.78	none	none			

N added through manure .90 dz/ha, through commercial fertilizer legumes and green manure 3.47 dz/ha. Total N in terms of ammonium sulphate 21.85 dz/ha. K_2O added through manure 2.00 dz/ha in terms of a 40 per cent potash salt 5.0 dz/ha.

Note: Beginning with the seventh year although it may still be possible to secure the 50 per cent "A" yields without additional P_2O_5, it will be well to return to the soil henceforth both K_2O and P_2O_5 in quantities equal to what is annually removed by the crop.

For those who desire to learn more of the Mitscherlich method of pot testing and application of results, the writer desires to make known that there is now in process of preparation a translation of Marquart on *Mitscherlich's Instruction on the Determination of the Fertilizer Requirements of the Soil.* The writer has drawn heavily on the following in the preparation of this article:

Mitscherlich—1925 Die Bestimmung des Düngerbedürfnisses des Bodens.
—1925 Ein Leitfaden zur Anwendung der künstlichen Düngemittel.
Marquart—1925 Eilhardt Mitscherlich's Lehre von Bestimmung des Düngerbedürfnisses des Bodens.

To thoroughly understand Mitscherlich's manner of arriving at a solution of the problems of chemical soil analysis through plant physiology, one must study all of the articles he has published. Translations of the above mentioned pamphlets will greatly assist those interested.

Chemical Control in the Construction of Hydraulic Earth-fill Dams

By F. E. Hance

The following paper deals with a description of the chemical control now in vogue in the building of the Alexander Dam, McBryde Sugar Company, Ltd., Eleele, Kauai, under the supervision of Joel B. Cox, engineer in charge of construction.

The control is maintained by the department of chemistry of the Experiment Station, H. S. P. A., in Honolulu, the data being periodically forwarded to Mr. Cox for his use at the building site.

This paper also contains a discussion of the researches of the department of chemistry which led to an inspection of several outstanding mainland hydraulic fill dams under construction or completed.

A chemical development in soil treatment, which was later adopted at the building site, is discussed.

The reactions of a few nationally prominent engineers and chemists to the chemical soil treatment scheme are included in the discussion.

Descriptions and photographs are shown:

(a) of two California dams during failure,

(b) of the unusually successful venture of the Miami Conservancy District, and

(c) of the construction operations at the building of the Saluda Dam in South Carolina (the largest hydraulic-fill dam in the world for power purposes).

At most elevated locations in the Islands the construction of a dam can be accomplished with the greatest economy by the hydraulic gravity sluicing of earth-fill material across a canyon stream bed.

At the site of the Alexander Dam the geological and topographical conditions of the locality favored the building of such a type of structure. Mainland undertakings of this character, after completion, have proven, in some cases to be sound earth structures, and in other cases have been entirely unsatisfactory.

An unusually successful and effective series of very large hydraulic-fill dams have been completed in the Miami Conservancy District in the vicinity of Dayton, Ohio. There are many other successful structures. On the other hand, two outstanding partial failures of this type of dam are those located at Lafayette and Calaveras in California.

In the construction control of the Alexander Dam, Mr. Cox took into consideration various engineering practices, developments and tests which had commonly or uncommonly been employed in other similar operations of this character. He found that a more exact and thorough knowledge would be required of the physical and chemical properties of the materials going into this dam if he were to maintain the project within the economic and safety limits as laid down in the specifications.

Aided by Messrs. Tester and Williams, Mr. Cox developed a scheme of soil testing which was later refined and expanded at the Experiment Station by bringing the various procedures within the control of fundamental laws in physical chemistry.

A system of engineering tests in soil mechanics had recently been described by Dr. Charles Terzaghi, of the Massachusetts Institute of Technology. By using original apparatus of special design, Dr. Terzaghi has shown that future predictions of consolidation and stability may be rather accurately made on fresh core materials intended for use in a hydraulic-fill structure.

Dr. Terzaghi's articles were published in the *Engineering News-Record* beginning November 5, 1925, and appeared weekly throughout the remainder of the year's publications.

Lacking laboratory facilities, equipment and operatives to investigate the Terzaghi developments for their possible control value at the site of the dam, Mr. Cox requested the Experiment Station to take up this work and combine it with the chemical researches which were already in progress at Honolulu. With G. R. Stewart's approval, the writer and C. W. Nesbitt, assistant chemist, thereafter cooperated with Mr. Cox in inaugurating a general scheme of chemical and engineering control, which was carried along and frequently modified during the building of the 50-foot pilot dam at the upstream toe of the proposed main structure. A study had been made in a classification of the soil materials which constituted the deposit (spoil bank) from which the fill for the dam was being sluiced.

A problem of selection in "beach" (coarse) and "core" (fine) materials was recognized at the outset. The spoil bank offered an almost unlimited supply of fill material, but it consisted of an heterogeneous agglomerate of widely variable physical characteristics. The colloidal character of this spoil bank soil was given a thorough study. A correlation between percentage of colloids, characteristics of "fines," settling out properties in aqueous suspension, soil reaction and other physical properties was gradually brought into a definite scheme of selective control. The coarse or "beach" material offered no problems of a chemical nature. The core which was being deposited in the pool of the dam constituted that portion of the structure which governed to a great extent the future stability of the entire project. Problems of settlement, consolidation, impermeability and rigidity were encountered which required a solution in terms of a future condition in the core after about 60 feet of new fill had been placed upon the then exposed elevation from which a sample had been withdrawn.

This requirement entailed the development of a means of securing data by chemical and engineering methods which amounted essentially to a schedule of predictions in the constants required. The accuracy of these predictions was subjected to as many reliable tests as could be devised. The whole scheme of control was then modified as far as possible to meet the requirements of the engineer, with the fewest complications of cumbersome technic.

By the time the pilot dam had been completed a comprehensive procedure of tests and determinations had been placed on a practical basis.

The newly developed scheme of control contained many features which were new in engineering use. On each core sample coming to Honolulu we were able to return the following information and data:

1. Reaction on the pH scale (acid or alkaline).

2. Settlement characteristics from a suspension in water and percentage of colloidal matter at different stages in the settlement.
3. Effect on true colloidal dispersion by neutralization of natural acidity with alkali and subsequent behavior when made quite alkaline.
4. Solubility characteristics of the material and its resistance to chemical change when in long contact with impounded water.
5. True specific gravity—a very valuable guide in detecting a material of poor packing qualities.
6. A minimum percentage of water content which will admit of:
   (a) a degree of plasticity compared to a standard (adhesive properties).
   (b) a degree of granulation at a point where the mass refuses to adhere when rolled out to a thin cylinder (brittleness).
   (c) a degree of "drying out" at a point where the mass cracks and fissures (cracking point).
7. A ratio of void spaces to solid material as the core is subjected to the load above it during construction.
8. The compression properties or elasticity of the core under increasing and decreasing loading.
9. The consolidation to expect of the material after it has been loaded with 60 feet (more or less) of additional core. (This range has recently been extended to 100 feet.)
10. The resistance to a movement of water under the conditions of 9 when subjected to a measured hydrostatic head of impounded water. This determination is made as a test of "permeability" and is separately determined for various increments of loading.
11. The microscopic examination of the material for shape of grain and colloidal dispersion and recorded for reference and description by micro-photographic methods.
12. Calculations and mechanical curve plotting of the mathematical data produced in the various tests.

All the above tests are separately made on the spoil bank deposits—the original material for sluicing into the core.

When applied to core material freshly laid down, the whole series of tests enables the engineer to secure an estimation of how that material is going to, or at least should, behave after it has gotten beyond his reach and has become a part of the dam. The rapidity of construction and factors of safety in the structure are thus made dependent, to a marked degree, on the results of the program of control.

During the course of the experiment work on the Alexander Dam cores at the department of chemistry in Honolulu, it was found that a treatment of the soil material with common alkali gave it the exceptional properties of high impermeability and apparently a plastic, clay-like consistency. Further researches on this treatment of the core soil gave indications that the idea might be used to practical advantage in preparing the fill for the core wall under the foundations of the main dam.

In excavating the core trench to bedrock for the core wall foundation, Mr. Cox

found that a layer of gravel several feet thick was situated below and was spread out parallel with the valley floor. The possibility existed that excessive seepage might eventually find its way through this gravel after the dam had been completed above it. It was recognized that a rapid movement of waters beneath the foundation of the dam would constitute a potential menace of undermining the entire structure. A manner of blocking this possible flow was proposed in surrounding the concrete core wall with the alkaline-treated core soil which had proved so dense and impermeable in the laboratory experiments. The plan involved the laying down of two longitudinal blankets of chemically treated soil across the core trench and on either side of the concrete cut-off wall. This operation would break the continuity of the under stratum of gravel and place in the flow path a V-shaped deposit of very impermeable fill, supported by the core wall in the center and trench cut on the sides. Consolidation properties of the alkaline-treated soil were found to be satisfactory and the permanence of the treatment itself was established as a dispersed condition of long duration with little likelihood of drastic change in this condition after consolidation.

A point had been reached in the building operations where sluicing had been stopped on the pilot dam preparatory to advancing with the main structure. The core trench was being excavated to bedrock.

Many features of the developed control program and the proposed chemical treatment of fill in core trench were not as yet described in the literature or in use at other projects, nor were they matters ever having been given engineering precedence or trial, as far as we could determine. It was proposed, therefore, that the plans be submitted to noted individual mainland authorities of national reputation and experience.

The development of the alkaline core treatment scheme to a point of possible utilization in dam construction was largely due to Mr. Stewart's encouragement in bringing the researches to a definite conclusion. He gave the investigation considerable of his personal attention and at the conclusion of the work he urged that the scheme be given every possible authoritative criticism before advising that it be adopted in the building program.

On March 18, 1929, the writer was authorized to visit such mainland individuals, institutions and construction operations as would insure a thorough and comparable investigation of similar continental projects. Criticism of our control program and proposed scheme of chemical soil treatment was also to be sought.

We carried the soil treatment scheme to the mainland authorities with Mr. Stewart's and the writer's firm belief in its usefulness but with open minds on its practical utilization. The trip was made and investigation completed between March 28 and June 11, 1929.

The report on the above trip is as follows:

Dr. Nathan A. Bowers (Ph.D. in Engineering):

Dr. Bowers is the Pacific Coast editor of the *Engineering News-Record,* with offices at the McGraw-Hill Building, 883 Mission St., San Francisco, California. Dr. Bowers had previously been advised by letter as to the objectives of the trip. In the first conference at San Francisco he offered his office as headquarters and urged that full use be made of his library and office force. He discussed the

Alexander Dam testing program and also the proposed alkaline core-fill scheme for use around the cut-off wall. He was enthusiastic in his endorsement of both schemes and stated that many features of the testing program and the proposal for chemical soil treatment were new to the engineering profession. He requested that we contribute a series of papers to the *Engineering News-Record* which would carry a description of the researches which led to the development of the control program and to the chemical soil treatment.

Dr. Bowers later made arrangements for the inspection of the Lafayette and Calaveras Dams, the San Leandro, San Pablo and Hetch Hetchy projects. He made introductions in person and by letter to various West Coast water project officials with whom the problems of the Alexander Dam were discussed.

Dr. Bowers was frequently consulted during the course of the investigation. His advice, assistance and influence were invaluable aids in realizing the objectives of the trip. The mainland itinerary was revised in his office. Many future appointments and introductions were very kindly arranged by letter from his office.

Mr. George W. Hawley, chief engineer, East Bay Water Company, Oakland, California:

Mr. Hawley has built several hydraulic-fill dams in northern California. He approved of the inspection of the Upper and Lower San Leandro projects as advised by Dr. Bowers, and also of the San Pablo Dam (all built by Mr. Hawley). He examined the control data and the proposed chemical soil treatment at the Alexander Dam. He related his experiences with hydraulic type of structure and pointed out details in construction in which he advised the exercise of the greatest of caution. The slope of the dam and design of spillway were, in his estimation, of vital importance. His suggestions on these constructional details were noted and sent to Mr. Cox. Owing to Mr. Hawley's wide building experience, information and criticism were particularly requested as to the design and height of the cut-off wall and propsed chemical soil treatment in cut-off trench at the Alexander Dam.

During the course of his reply he stated: "If cut-off wall serves only as a baffle its height is of importance in creating a longer path of underground seepage. If, on the other hand, you intend to surround the wall with the highly impermeable and chemically treated soil, a shorter height will suffice."

Mr. Hawley approved of the scheme of surrounding the core wall with the alkaline-treated soil fill. He asked, however, what proof we had that a reversible reaction would not eventually cause the treated soil to revert to its original condition. In reply the colloid dispersion phenomenon was explained in some detail, showing the almost complete disintegration of granular soil to an impalpable fineness by the treatment, and of the difficulty, after consolidation, of any water or solution reaching beyond the inner surfaces of the soil in mass. This point had been previously settled by experiment in Honolulu. Mr. Hawley's interest in the Alexander Dam may be shown by the fact that he requested two days' examination of plans and data before the discussion of the project.

Mr. Hawley very kindly also offered to conduct the writer's inspection of the San Pablo structure in person.

Dr. Charles Terzaghi, Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology, Boston, Mass.:

A large proportion of the control measures being employed at the Alexander Dam were derived from Dr. Terzaghi's published articles and from Professor Andrews' (University of Hawaii) lecture notes on Terzaghi concepts. Professor Andrews also very kindly assisted us in inaugurating the Terzaghi tests and loaned us his apparatus for the work.

All the data of the control measures, proposed chemical treatment of core wall fill and construction plans of the Alexander Dam were submitted to Dr. Terzaghi in Boston.

Four days were spent with him in his laboratories. He discussed at length the application of control measures for hydraulic-fill dams and also took up the subject of the alkaline core fill in the cut-off trench at the Alexander Dam. He expressed unqualified approval of the chemical soil treatment for the purposes which were described. He pronounced the scheme as unique and showed by explanatory sketches and mathematical calculations how the treatment would be of value when confined in the core trench, but of little value in the main dam without unusually heavy beach superstructures.

(The proposed treatment included only the V-shaped wedge on either side of the core wall below the valley floor.) Dr. Terzaghi's aides, Dr. Glennon Gilboy and A. Casagrande, gave us very valuable information and instruction in operating the Terzaghi apparatus and in conducting the tests. This information was of the greatest importance because of the fact that it is still unpublished and is not obtainable from any other source.

As a result of the experiences with these gentlemen in Boston, our program of testing in Honolulu has been given the benefit of their many years of research in the applications of Terzaghi's theories. We have since endeavored to bring our technic to a point comparable with the advised refinement given us by Dr. Terzaghi, Dr. Gilboy and Mr. Casagrande.

The interest shown in our core problems by these gentlemen prompted them to request that we forward them several samples from the Alexander Dam for a check on our results and a study of the effect of the proposed chemical treatment. Mr. Casagrande will make these studies in Vienna, Austria. This move is necessitated by the laws prohibiting the importation of Hawaiian soil to the mainland of the United States. We have forwarded the requested soil samples to Austria via Canadian routing.

Dr. Terzaghi has tentatively accepted an invitation to inspect the Alexander Dam in August, 1929. He will probably stop off in Honolulu on an already arranged trip to Japan.

During the stay in Dr. Terzaghi's laboratories, opportunity was found to note in writing many of the recommendations and suggestions which he advised for the testing program and for procedure at the dam. These notes have been passed on to Mr. Cox.

It appeared important to obtain the opinion of a group of experts in chemistry on a soil treatment which now had the endorsement of several prominent engineers. If used at Kauai, the scheme would involve the handling of about 2,000 tons of core soil and the purchase of about 50,000 pounds of soda ash.

The decision was reached to submit the scheme to the staffs of the department of chemistry and of the department of agriculture at Cornell University after the conclusion of the interviews with Dr. Terzaghi. Accordingly, a stop-over at Ithaca was made in moving southward from Boston.

Professor L. M. Dennis and Staff, Department of Chemistry, Cornell University, Ithaca, New York:

The relationships of physical and inorganic chemistry to the control program and to the alkaline soil treatment were looked into by these gentlemen. Professor Dennis expressed an agreeable surprise to find a chemical control and soil treatment so closely associated and so interrelated with an engineer's mathematical soil testing scheme. Professor Dennis and other staff members stated that the chemical measures of the testing and soil treatment in Honolulu were sound as far as they could judge by the description given and data submitted. The alkaline soil treatment scheme met with enthusiastic comment. The departure from the conventional in this respect was discussed but no objection was offered as to the soundness of the theories involved.

Professor T. L. Lyon and Staff, Agricultural College, Cornell University, Ithaca, New York:

These gentlemen discussed the proposed alkaline soil treatment from the agricultural chemist's viewpoint. Dr. B. D. Wilson suggested that the scheme, in his opinion, was entirely practical and would produce a dispersion in the soil colloids which would remain "put" indefinitely under the conditions of its use.

With the accumulated information and advice at hand from different sources and all endorsing the chemical soil treatment, it was deemed advisable to suggest to the engineer at the Alexander Dam to proceed with the treatment. Alexander and Baldwin, Ltd., agents for McBryde Sugar Company, Ltd., were advised by wire and Mr. Stewart, head chemist, Experiment Station, H. S. P. A., by letter, of the expert advices which had been received. Mr. Stewart, having previously considered the advisability of placing the treatment in the dam, reported further to the builders, suggesting the details and manner best suited for its utilization.

Mr. Nesbitt, assistant chemist, later cooperated with the McBryde Sugar Company, Ltd., in placing the treatment in the core trench.

Mr. F. E. Schmitt, editor, Engineering News-Record, MrGraw-Hill Publishing Company, 10th Avenue at 36th Street, New York City.

Dr. Bowers had advised Mr. Schmitt that a call would be made on him in New York. The details of the soil treatment scheme and testing program were discussed with Mr. Schmitt and other staff members of the McGraw-Hill organization.

The alkaline soil treatment idea appealed to Mr. Schmitt as a very worthwhile undertaking. He showed keen interest in the chemical control and soil testing program. He complimented Mr. Cox on the originality of many of the control measures and expressed regret that similar studies were not in vogue in New York City on the soil foundation problems then giving trouble in upper Manhattan Island. Mr. Schmitt particularly requested that we submit a paper (or papers) which would carry descriptive matter of the theoretical and practical application of

chemical soil problems to foundation structures. He stated that this type of investigation has never been made for the use of the engineer. He stated that the problems in soil chemistry as applied to soil mechanics is an untouched field. He then cited instances in New York where an understanding of soil chemistry would undoubtedly have contributed to the solution of many troublesome foundation problems. Timely suggestions on asphalt reservoir lining and introductions to Eastern officials were secured at the McGraw-Hill office.

Mr. Schmitt and Mr. Richardson also very kindly arranged details of transportation, introductions, etc., for the inspection of the Saluda Dam in South Carolina.

The Saluda River Project—Columbia, South Carolina:

This is the largest hydraulic-fill dam in the world designed for power purposes, Murray and Flood, engineers, builders; A. R. Wellwood, resident engineer; J. G. Wardlaw, Jr., testing and control; Hamby, Darlington and Duncan, engineers.

The Saluda River Dam is at present under construction, in charge of Mr. Wellwood. The problems of hydraulic fill are here seen on an enormous scale. The crest of the dam when completed will extend somewhat over 1 1/3 miles in total length and the basin will cover seventy-eight square miles. The manner of sluicing the core material into place differs from the gravity flow scheme in use at the Alexander Dam. The upper and lower toes of the dam are simultaneously being constructed as dykes from which material for the core pool between is sluiced by a giant (water) discharge.

Seventeen trains on a standard gauge track are continuously hauling and dumping the soil fill from several "borrow pits" to the two parallel dykes. The water giants are operated from floating pumping stations. Pontoons in the central core pool carry a frame rigging, the latter supporting electric power cables used to convey electric current to the pumps which drive the giant discharge mechanism. As construction advances the rising pool floats all the units used for sluicing down the dykes.

The Saluda River, a large stream, has been diverted through arched conduits under the floor of the dam. These conduits will later serve as outlets in operating the hydro-electric generators.

Five concrete towers have been constructed to house the machinery for the operation of the gates at the entrance to the outlet tunnels. Mr. Wellwood has described the project very completely in *Engineering News-Record,* Vol. 102, No. 17, April 25, 1929, pp. 669-672.

Our chief interest in this project was one of comparison of materials and manner of construction with the Alexander Dam.

Mr. Wellwood very kindly extended every possible courtesy and aid for a very thorough inspection of the undertaking. Messrs. Hamby, Darlington and Duncan separately conducted tours of inspection in which different phases of the project were explained.

Mr. Wardlaw gave us a detailed account of the testing and control program at Saluda and made provision for obtaining samples of materials for comparison with Alexander cores.

The comparison investigation is in progress at this writing (July 5, 1929).

We are also exchanging ideas on methods of control and testing. We are expecting to find information of value to both projects after the comparison data have been compiled and studied.

Information of added value will no doubt be developed when these projects are compared with the testing data from Miami Conservancy, Lafayette and Calaveras Dams.

Unfortunately for us, Mr. Wellwood was very busy with conferences and executive detail during the brief stay in Columbia. Consultation was only possible on a few occasions of short duration. He expressed regret that he could not, at that time, go into a full discussion of our proposed soil treatment and testing program. We are, at present, corresponding with Mr. Wellwood and with Mr. Wardlaw on these matters.

A few photographs are shown which Mr. Wellwood permitted us to take and to use for illustrative purposes in this report.

The Miami Conservancy District, Dayton, Ohio:

This district is a political subdivision of the state of Ohio established in 1915 and exists for the purpose of building and maintaining flood control works in the Miami Valley. The history of the valley is replete with accounts of serious floods. In March, 1913, the Miami Valley was swept by a tremendous storm. The streams of the valley, fed by the steady downpour, rapidly rose and overtopped the levees. For three days the waters raced through the streets of Dayton, reaching a depth of twelve feet in Main Street at the peak of the flood. Thousands of people were marooned in attics and on roofs of houses, 400 lives were lost, 100 million dollars of property was destroyed, and the communities of the valley were rendered prostrate.

As a result of this calamity, the Conservancy District was established. The official plan provided for five basins formed by building hydraulic earth-fill dams across the streambeds which carried the flood waters. Substantial concrete outlets, founded on rock and passing through the base of each dam, permit the ordinary river flow to pass unobstructed. The sizes of the outlets are such that at times of highest floods, only such amounts of water will escape through them as can be safely taken care of in the river channels below the dams. The excess water is held back by the dams and accumulates temporarily in the valley lands situated above them, to flow off later through the outlets as the floods subside. Storage is designed for a total of 847,000 acre feet of water under maximum flooding conditions. Spillways are provided at all of the structures in order to keep the water level from reaching the crest of the dams, should such a flood come.

Inspections of these projects were made possible through the courtesy, cooperation and assistance of C. S. Bennett, in charge of the district, and of C. A. Bock, vice president, Morgan Engineering Company, the builders.

The materials which were used in the cores of the dams were examined and sampled at the borrow pits. Attention was given to the details of spillways and the outlets. All the dams appeared to be massive and secure. Ample evidence was given by the layers of debris within the basins to show that the dams had frequently functioned as the builders had planned. In no case had the impounded water ever risen to the elevation which would carry it over the spillway. The entire project has proven safe and secure. Since its completion the cities in the

Miami Valley have not only been free from any flood menace, but are guaranteed immunity in the future. Mr. Bennett stated that the spillways would not automatically operate until a flood came which would be 40 per cent greater in intensity than the 1913 disaster.

The materials from the Germantown structure are to be compared in a full testing program with the Alexander Dam and with the other mainland projects visited.

Both Mr. Bennett and Mr. Bock discussed the constructional features of the Alexander Dam with the writer. They very kindly made recommendations and offered valuable advices which we have passed on to Mr. Cox on Kauai.

Mr. Bennett issued a pass which gave the writer admission to all five projects, with permission to sample and photograph at will. Mr. Bock generously gave up half of his Sunday holiday, driving the writer to the three largest dams and stopping in each case for an inspection and explanation of constructional details and operating features.

The photographs taken at the dams of the Miami Conservancy District are shown herewith:

The Lafayette Dam, Lafayette, California:

The following brief description of this dam and its partial failure during construction is made possible through the courtesy of F. W. Hanna, superintendent of the East Bay Municipal Utility District of Oakland, California.

Mr. Hanna very kindly presented the writer with his personal copy of the "Report by the Consulting Board on Partial Failure During Construction of the Lafayette Dam."

This report is a very complete and beautifully arranged thesis. It contains a description of the dam, an estimation and analysis of the causes leading to its partial failure, a series of photographs which amplify the text and a recommendation for the correction of the failure with a full complement of descriptive charts and prints.

The Lafayette dam is situated in Contra Costa County, California, about 9 miles northeast of the City Hall of Oakland.

The dam, an earth embankment, designed to be 140 feet high, 1,400 feet long, extends in a nearly east and west direction across a small creek valley tributary to the Lafayette branch of Walnut Creek. The dam is a unit of the Mokelumne Project of the East Bay Municipal Utility District, and was intended to provide storage for 3,460,000,000 gallons (10,590 acre feet) of water to be pumped into the reservoir from the main aqueduct which passes through the valley of the Lafayette Branch of Walnut Creek. Construction was begun in August, 1927, and on September 17, 1928, when the dam lacked only about 22 feet of its intended height, a crack parallel with the axis, and a rise in elevation of the ground surface, were observed at the downstream toe of the embankment. Additional cracks soon appeared and the embankment began to subside until, on September 28, all appreciable movement had ceased, after the central part of the dam had sunk a maximum of about 24 feet at the crest. . . . The foundation under that part of the dam where the failure occurred is an alluvial deposit composed very largely of clay, with a depth ranging from 50 to 90 feet above the Orinda formation. The upper 10 to 15 feet of this material was dry and firm, but the remainder was moist and more or less plastic.

. . . . the fact that the dam rests directly on the plastic alluvium which in the deepest part of the dam is 90 feet or more in thickness, is, from the point of view of the geologist, the critical factor in the failure of the structure.

Through the courtesy of George B. Sturgeon, engineer in charge at the site, the writer was given the privilege to inspect, photograph and sample the structure as it now stands. Mr. Sturgeon very kindly conducted the inspection trip and assisted in securing the exhibits which are to be used as illustrative material in the general mainland investigation.

After a discusison of the project with Mr. Sturgeon, notes were later made which appear below:

> Lafayette—slip-on dam—apparently due to alluvial sub-foundation. Abutment sides gave good bond where bedrock came close to surface. Valley floor was poor in some places—bed rock occurring probably more than 90 feet below surface. The dam (roll fill) slumped at core and bulged out at both toes. No flow of water occurred. Construction was not complete nor had spillway been built at time of failure. Repairs have been decided on. See Mr. Hanna at Oakland office.

It should be made very clear that the "notes" above do not quote Mr. Sturgeon's remarks. They are simply notations on impressions which remained on the evening of the day spent with Mr. Sturgeon as his guest.

While the slight failure was not due to a liquid core nor to any other inherent defect in the materials of the dam, samples were secured of core and borrow pit deposits which we plan to study in comparison with the other mainland projects visited and with the Alexander Dam at Eleele, Kauai.

The photographs appear herewith. Most of these prints have been reproduced from original photographs by W. Twigg Smith, illustrator at this Experiment Station.

Many of the photographs were obtained from the report presented to the writer by Mr. Hanna.

The Calaveras Dam, near Sunol, California:

This dam has a very interesting history. As it now stands, it has a height of 220 feet above bedrock, and encloses a reservoir area having a capacity of almost 33 billion gallons of water. The project is a part of the system which supplies the city of San Francisco with water. The lower portion of the dam was built by the hydraulic-fill method. When nearing completion, a part of the main core broke through the beach and flowed upstream. The tower which carried the mechanism to operate the outlet gates was snapped off at the base, moved 360 feet, and thrown over. The downstream face of the dam, the berms and supporting fill practically remained intact. No serious property damage, other than the injury to the structure, was occasioned by the break. But little water stood in the reservoir at the time of the core flow and as a result no flood occurred and no lives were lost.

The dam has been repaired and the project has been completed, using the roll-fill method of laying down the remainder of the core, which is supported by loosely dumped rock to form the complete structure.

A new tower and outlet tunnel have been constructed, as well as a most effective and substantial concrete spillway. The structure now stands as one of the most massive, secure and beautifully ornamental sites on the West Coast.

Through the courtesy of George A. Elliott, vice-president and chief engineer of the Spring Valley Water Company, an inspection of the project was granted. Mr. Elliott also very kindly prepared and presented us with a series of photographs showing the details of the flowout, the repairing of the dam and the finally com-

pleted structure. Mr. Elliott also introduced the writer to A. W. Ebright, superintendent of the Calaveras District, and arranged with Mr. Ebright for an inspection of the project. Through Mr. Ebright's courtesy and assistance, a sample was secured of the orginal core which flowed out in the break. Other samples were collected which were removed from the borrow pits used for hydraulic fill and from the deposits later used for the roll fill. These materials will be studied in comparison with the other mainland projects visited and with the cores of the Alexander Dam on Kauai. Reproductions of the photographs presented to us by Mr. Elliott follow. The negatives from the original prints were prepared by Mr. Smith, as in the case of the Lafayette photographs.

The construction plans and control program of the Alexander Dam were discussed with Messrs. Elliott and Ebright. Mr. Cox has been advised on the reactions of these gentlemen to the project on Kauai.

Many other projects and water systems were visited. A study was made of the manner of dam construction and spillway design at:

The Municipal Project of the Wichita Falls (Texas) Water District.
The Upper and Lower San Leandro basins in Northern California.
The San Pablo District of California.
The Hetch-Hetchy District of California.
The Municipal Water Systems of Boston, New York City, Ithaca, Philadelphia, Baltimore, Washington, Cincinnati, New Orleans, San Francisco and Los Angeles.

The experiences gained at the above-mentioned projects were varied. An attempt was made to learn of the difficulties encountered during the construction of the various dams.

In the eastern districts of the mainland the relatively denser population necessitated the construction of water systems of gigantic capacity. Most of these projects were built with reinforced concrete. Smaller basins of the hydraulic or roll-fill type were numerous, but the soil conditions were so favorable and funds so freely available that serious problems of dam security were seldom encountered.

The problem of sewage disposal and water contamination are engaging the principal attention of the Eastern water engineers and city officials.

In many of the large cities the water supply is pumped from a near-by river, filtered, chlorinated, and turned into the mains—all in one continuous process.

A few cases of seepage problems were found in the East, many in the West. This matter will be discussed in the report on reservoir sealing and ditch lining. Wherever time permitted and the engineer was so inclined, an opinion was obtained on the construction and control problems of the Alexander Dam.

Many systems of riprapping, grouting and plugging of subterranean tubular vents in dams and reservoirs were inspected and discussed with some of the engineers visited.

The courteous attention and kindly interest shown the writer on this mission by every individual or institution official visited, assisted greatly in obtaining the information and experiences which were sought.

A paper will appear later in which a comparison study of the materials of mainland and Hawaiian dams will be discussed.

Fig. 1. Saluda Dam, Columbia, South Carolina.
Upper core pool area.
Saluda River in distance.
Two toes under construction.
May 1, 1929.

Fig. 2. Saluda Dam, Columbia, South Carolina.
Towers in background. One of the core pools in right foreground. Top of towers represent approximate height of dam when completed. Towers contain mechanism for operating outlet gates in control of the hydro-electric plant now under construction.
Saluda River is at present flowing under construction work in a series of tunnels at base of towers.
May 1, 1929.

Fig. 3. Saluda Dam, Columbia, South Carolina.
Discharge of borrow-pit material. Giant in operation.
Pontoon floats in foreground. Source of pool is muddy water from Saluda River. Water in pool becomes clarified by contact with the borrow-pit fill. (Note clear water and white discharge from Giant). (The cause of this phenomenon is under investigation in this laboratory.)
May 1, 1929.

Fig. 4. Saluda Dam, Columbia, South Carolina.
Central core pool.
Upstream and downstream toes.
Floating pump houses.
Train carrying borrow-pit fill.
Pontoons supporting power cables to operate pumps for giants.
May 1, 1929.

Fig. 5. Saluda Dam, Columbia, South Carolina.
Giants in operation.
Details of pontoons.
Showing both dykes and the core pool between toes.
May 1, 1929.

Fig. 6. Miami Conservancy Project.
Declaration of purpose.
May 4, 1929.

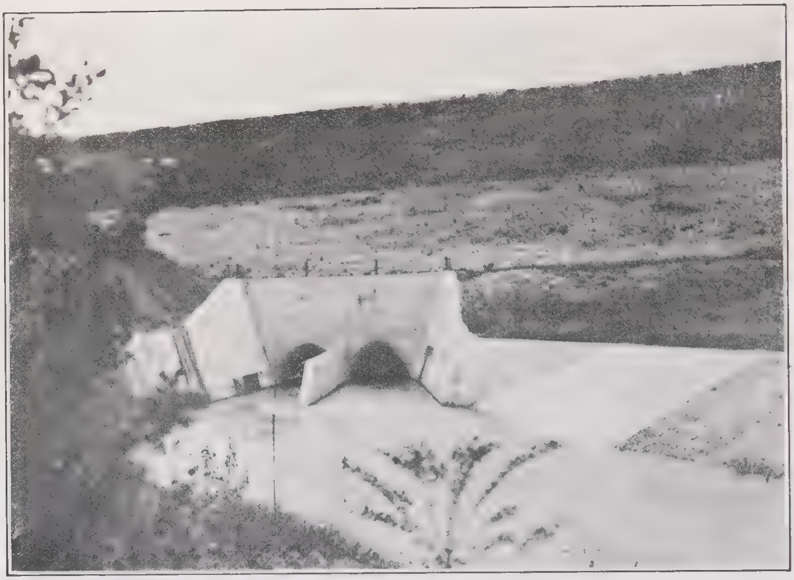

Fig. 7. Miami Conservancy Project—Germantown Dam.
Intake—diversion tunnel. Showing upstream face of dam and railing beside road across crest.
May 5, 1929.

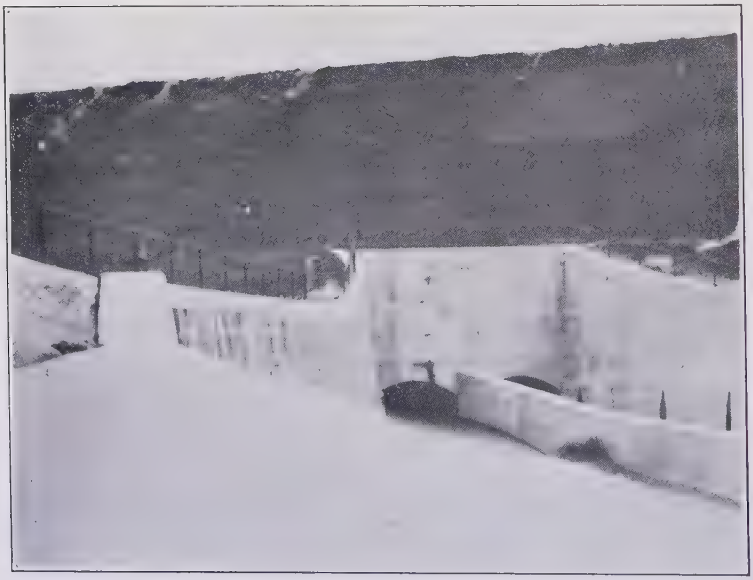

Fig. 8. Miami Conservancy Project—Germantown Dam.
Outlet—diversion tunnel. Showing downstream face of dam and mechanical concrete device to reduce turbulence in stream discharge.
May 4, 1929.

Fig. 9. Miami Conservancy Project—Germantown Dam.
Spillway—constructed so as to operate automatically when peak flood waters reach volume 40 per cent greater than 1913 record.
May 5, 1929.

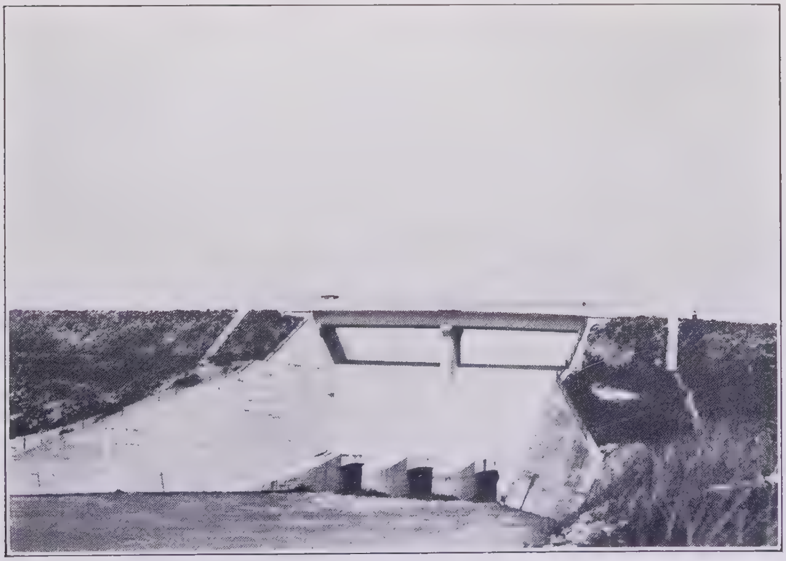

Fig. 10. Miami Conservancy Project—Huffman Dam.
Stream outlet, spillway, road and downstream face of dam.
May 5, 1929.

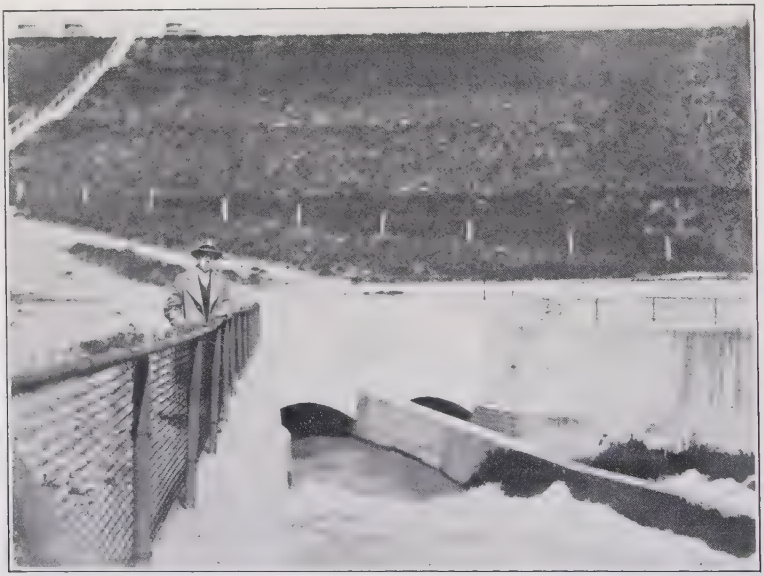

Fig. 11. Miami Conservancy Project—Englewood Dam.
Showing stream cutlet, road on crest and downstream face of dam.
May 5, 1929.

Fig. 12. The Lafayette Dam—
Airplane view of the partial failure showing slump in the crest and bulge at both toes.

Fig. 13. Lafayette Dam, October 21, 1928.
Ridge pushed up at the downstream toe, seen from the east. At left may be seen a portion of the dam that has been thrust out over the original ground surface in the foreground.

Fig. 14. Lafayette Dam, October 21, 1928.
Subsidence along crest of dam as seen from the west. The principal limiting fissure which cuts a segment from the upstream slope appears on the right.

Fig. 15. Lafayette Dam, October 21, 1928.
View eastward along crest of dam, showing crescent-shaped zone of fissures. The surface of the down-dropped block north of the fissure zone is tilted downward in an upstream direction.

Fig. 16. Lafayette Dam, October 21, 1928.
Crevasses in upper part of the downstream slope of the dam, looking east.

Fig. 17. Lafayette Dam, October 21, 1928.
Looking down the upstream face, showing buckling and overthrusting of the concrete facing.

Fig. 18. Lafayette Dam, October 21, 1928.
Upstream slope of dam, looking west.
Showing relatively slight movement of concrete facing.

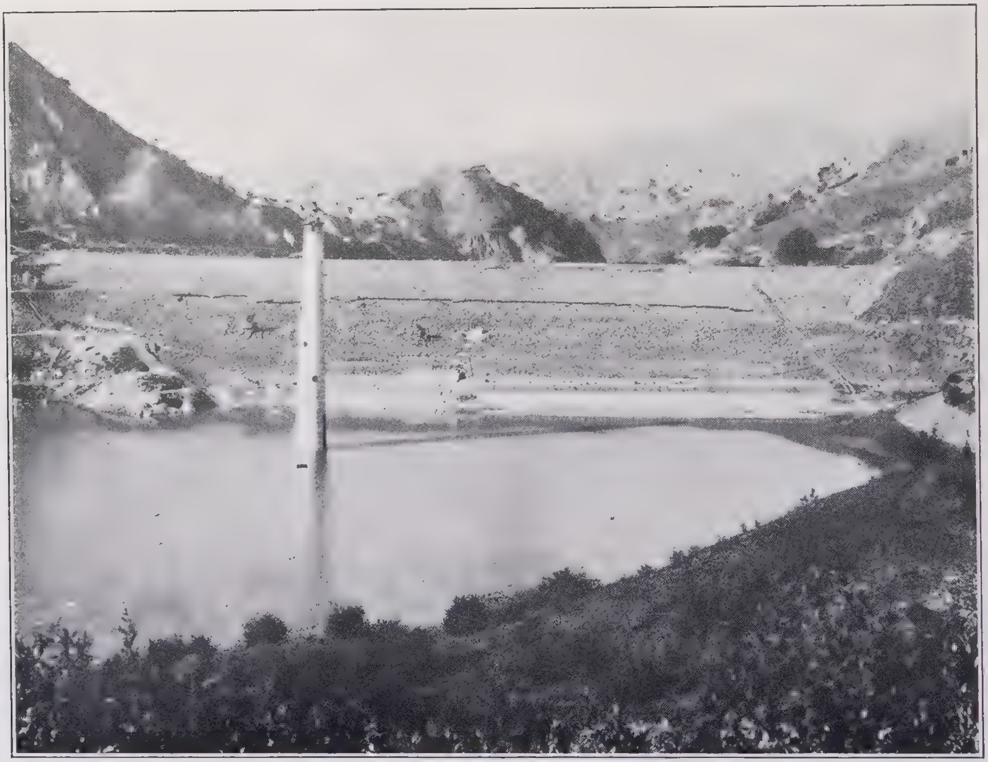

Fig. 19. Calaveras Dam—view before break.
Tower in foreground was carried upstream in upright position for 360 feet. It then toppled over and broke in three pieces (see Fig. 19A).

Fig. 19A. Calaveras Dam.
Showing location of tower after break. Earth dike at end of tower was placed afterwards in order to pump out section and recover gates. Caisson sunk through 50 ft. of slide, landed on tower foundation and connected with outlet tunnel to form temporary spillway which served during reconstruction.

Fig. 20. Calaveras Dam.
After the break. Note disappearance of tower and subsidence of upstream part of dam.
Downstream toe and beach remain intact.

Fig. 21. Calaveras Dam.
A close-up of break.
Debris, trucks, timber and implements were carried into the pit.

Fig. 22. Calaveras Dam.
Airplane view of break.
Showing relatively little damage to downstream face and berms.

Fig. 23. Calaveras Dam.
Portion of clay core trapped in the interior of dam.

Fig. 24. Reconstructed Calaveras Dam.
A downstream view of the spillway.

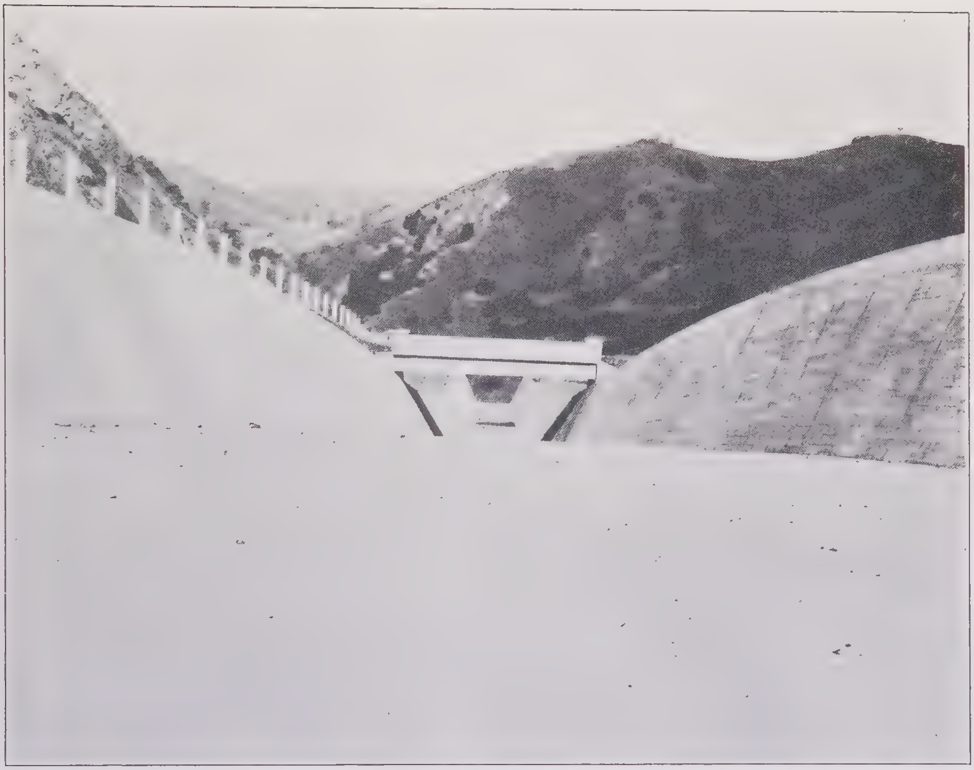

Fig. 25. Reconstructed Calaveras Dam.
View at spillway looking downstream from crest.

Fig. 26. Reconstructed Calaveras Dam.
Descriptive Tablet.

Fig. 27. Calaveras Dam.
Repair operations.
Hard stone riprap going into place.

Fig. 28. Reconstructed Calaveras Dam.
Showing completed upstream face and berm.
New outlet tunnel and tower in background.

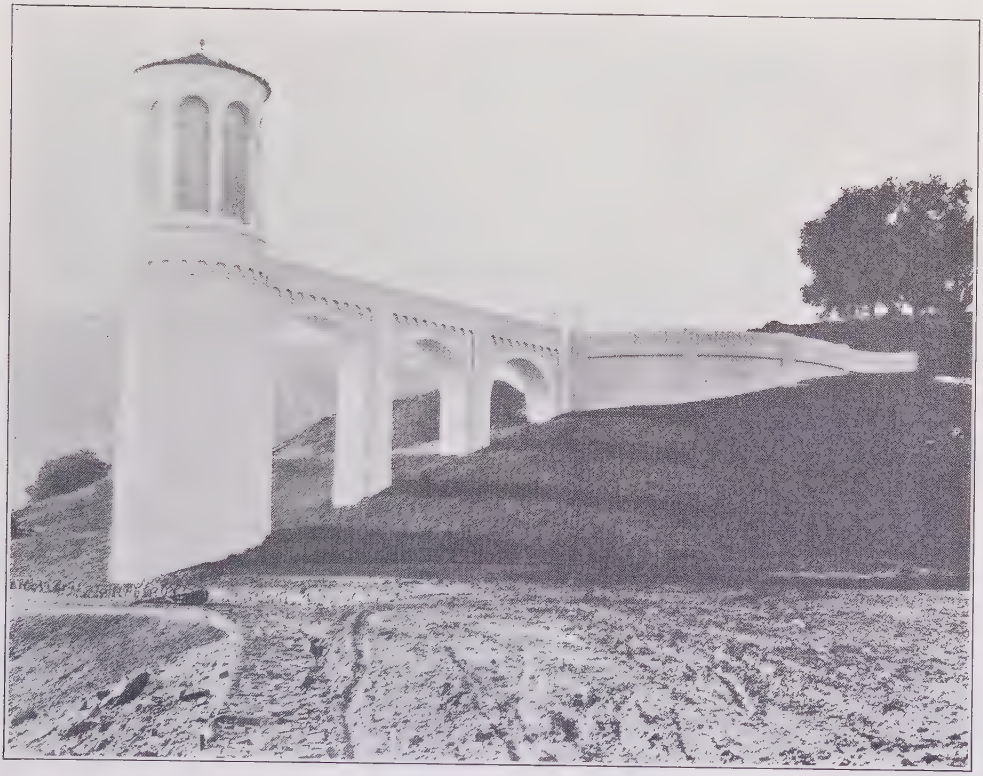

Fig. 29. Calaveras Dam.
View of new tower. December, 1925.

Fig. 30. Reconstructed Calaveras Dam, 1926.
A general view of downstream side of dam showing roads, berms, spillway, towers, etc.

Fig. 31. Calaveras Dam in 1926.
A general view of the reconstructed dam with the reservoir in service.

Fig. 32. Calaveras Dam in December, 1925.
A downstream view of the dam in service.

The Fourth Pacific Science Congress

By R. H. Van Zwaluwenburg

The Fourth Pacific Science Congress convened in Java from May 16 to 25, 1929, the inaugural meeting being opened by His Excellency the Governor-General of the Netherlands-Indies, at Weltevreden, Batavia. The Congress was then transferred to the mountain city of Bandoeng, where the remaining sessions were held in the buildings of the Technical Faculty. The Congress was held under the auspices of the Netherlands-Indies Science Council, and was supported by the high patronage of the Netherlands-Indies Government. The first Pacific Science Congress was held in Honolulu in 1920, the second in Sydney in 1923, and the third in Tokyo in 1926.

The following officers presided over the activities of the Congress in Java: General President, Dr. O. de Vries, Director of the Rubber Experiment Station, Buitenzorg; General Vice-President, Dr. J. Clay, Professor of Physics at the Technical Faculty, Bandoeng; First General Secretary, Dr. H. J. Lam, Herbalist of the Botanical Gardens, Buitenzorg; Joint General Secretary, Dr. H. J. T. Bijlmer, Military Surgeon, Batavia; and Treasurer, Dr. H. M. Hirschfield, Java Bank, Batavia.

The chairmen of the three divisions under which the Congress functioned were: Division of Physical Sciences, Mr. A. C. de Jongh, Director of the Geological Survey, Bandoeng; Division of Biological Sciences, Dr. W. M. Docters van Leeuwen, Director, Botanical Gardens, Buitenzorg; and Division of Agricultural Sciences, Dr. J. J. B. Deuss, Director, Tea Experiment Station, Buitenzorg. The divisions were divided into the following sections:

Physical Sciences: astronomy, geography, geology, meteorology, oceanography, palaeontology, petrography, radio-telegraphy, seismology and volcanology.

Biological Sciences: anthropology, botany, ethnology, fisheries and zoology.

Agricultural Sciences: foresty, phytopathology and soil technology.

Over 250 delegates and participants attended the Congress from overseas, besides a large number of scientific workers from the Netherlands-Indies. Besides those named in the preceding paragraphs, delegates from the Netherlands East Indies were: Dr. J. Boerema, Director of the Royal Magnetic and Meteorological Observatory; Dr. K. W. Dammerman, Chief, Zoological Museum and Laboratory, Buitenzorg; Dr. H. C. Delsman, Director, Marine Biological Laboratory, Batavia; Dr. H. Gerth, Geological Survey, Bandoeng; Dr. W. F. Gisolf, Petrographer, Geological Survey, Bandoeng; Dr. G. van Iterson, President, General Agricultural Syndicate, Batavia; Dr. B. J. O. Schrieke, Professor of Ethnography at the Faculty of Law, Batavia; Dr. C. E. Stehn, Chief, Volcanological Survey, Bandoeng; Dr. P. van Stein Callenfels, Inspector, Archeological Service, Ngebel, Ponorogo; Dr. J. Stroomberg, Chief, Division of Commerce, Department of Agriculture, Industry and Commerce, Buitenzorg; Dr. J. H. F. Umbgrove, Geologist, Geological Survey, Bandoeng; Dr. J. Verwey, Zoologist, Marine Biological Laboratory, Batavia; Dr.

S. W. Visser, Sub-director, Royal Magnetic and Meteorological Observatory, Batavia; Dr. J. T. White, Chief, Pedological Institute of the General Agricultural Experiment Station, Buitenzorg; and Dr. R. Wind, Director, Forest Research Institute, Buitenzorg.

Among the delegates from Holland were Dr. L. F. de Beaufort, Director, Zoological Museum of the Royal Zoological Society, Amsterdam; Dr. H. A. Brouwer, Professor, University of Amsterdam; Dr. E. van Everdingen, Director, Royal Netherlands Meteorological Institute, De Bilt; Dr. J. Jeswiet, Professor of Plant Taxonomy, Academy of Agriculture, Wageningen; Lieutenant-Commander F. Pinke, Royal Netherlands Navy, Commander S. S. "Willebrord Snellius"; Jhr. Dr. A. Roell, Provincial Governor of North Holland; Dr. W. J. K. Roepke, Professor of Entomology, Academy of Agriculture, Wageningen; and Dr. F. A. F. C. Went, Professor of Botany, University of Utrecht.

The American delegation, headed by Dr. T. Wayland Vaughn, Director of the Scripps Institution of Oceanography, La Jolla, California, included Mr. George Arceneaux, Dr. Leo H. Baekeland, Dr. Frederick V. Coville, Dr. Andrew C. Lawson, Dr. R. D. Rands, Dr. Oswald Schreiner, Dr. W. A. Setchell, and Dr. Philip S. Smith. Dr. C. Montague Cooke, Jr., led the Hawaiian delegation. Those in attendance from Hawaii were Dr. and Mrs. C. Montague Cooke, Jr., and Dr. E. Christophersen from the Bishop Museum; Mr. and Mrs. E. M. Ehrhorn,

Phytopathology Section, Pacific Science Congress, Bandoeng, Java
Front row (left to right): Roepke, Matsumura, Ehrhorn, Kuwana. *Second row*: Karny, Hazelhoff, Leefmans, van der Goot, Uichanco, South, Hoffman, Van Zwaluwenburg, Ochse. *(Photo by Dr. Roepke.)*

representing the Federal Horticultural Board; and Dr. A. J. Mangelsdorf and R. H. Van Zwaluwenburg from the Experiment Station, H. S. P. A.

Various excursions were arranged for the delegates, both before and during the period that the Congress had its headquarters at Weltevreden. Among these were field trips to Buitenzorg to inspect the famous Botanical Gardens, and to the numerous governmental and private scientific institutions located in that city.

An outstanding feature was the two-day excursion to Krakatau Island, lying between Java and Sumatra. This volcano exploded with terrific violence in August, 1883, covering the island with hot ashes and pumice stone to a depth of from 30 to 60 meters. Dutch scientists have paid particular attention to the reestablishment of plant and animal life on Krakatau since the catastrophe. Professor Docters van Leeuwen considers it probable that all plant life was destroyed by this convulsion of nature, and that all the present elements are derived from imported plants, spores and seeds. Verbeek visited the island two months after the eruption and found not a single plant; a year later he found only a few shoots of grass. Between 1908 and 1928 Dr. van Leeuwens found 276 plant species established. There is evidence that this increase has been very gradual, going hand in hand with the increasing suitability of the environment. He outlines the succession of plant occupation as follows: When the whole shore and the volcanic cone were bare, only such plants could grow which can survive on such exposed places. Then followed plants whose seeds and fruits were distributed by the agency of animals, and in the first place such sorts as are the first to come up on an open, secondary terrain. "One must take it, of course, that the seeds of all these plants were not brought in only when circumstances were favorable, but, rather, that they were being constantly carried in but could only strike root when the environment was favorable for their survival."

In discussing the problem of the fauna of Krakatau, Dr. K. W. Dammerman concludes:

1. There is every reason to believe that the fauna was totally destroyed in the eruption of 1883.

2. The sequence in which the different species have since populated the island is probably as follows: first detritus forms, next plant-eating species, and, finally, carnivorous and parasitic forms. This only means that the animals have established themselves in such consecutive order and not that they reached the island in that sequence.

3. The conditions on the island today, in respect of the fauna, are still not yet normal. Some animal groups, for example, winged forms like birds and insects, have probably reached 50 to 60 per cent of what may be regarded as the norm; the same is true of the soil fauna. Other groups, like the moss fauna, may be regarded as fairly normal already.

4. In the first place, creatures reached the island by air, either actively flying or passively transported by the wind; in the second place by sea, either swimming or carried along with driftwood or other flotsam; in the third place, by the agency of other animals or man. The last-named agency has played a very insignificant part in the case of Krakatau, while arrivals by air may be put down at about 90 per cent of the island's fauna today.

5. Whether it is animals from Java or Sumatra that have found a home on this island cannot generally be known. The great majority of the species now found on Krakatau are extremely common and very widely spread.

6. Since on the islands of the Krakatau group a few sub-species of one and the same species occur together, or species exist here under conditions that vary from the normal, it is not impossible that we shall be able to observe here the origin of peculiar sub-species or the varying of species.

The opening session of the division of agricultural sciences was devoted to a discussion of the rice problem around the Pacific. Papers were read on the following subjects: irrigation and drainage, manuring and selection of the rice plant; treatment of the rice crop and the harvest, soil management and tillage, and pests and diseases of the rice crop.

Dr. P. van der Goot of Buitenzorg contributed a paper on "Pests of the Rice Crop Around the Pacific," including a discussion of the most important enemies of the crop in the Dutch East Indies. There the white rice borer *Scirpophaga innotata* Walker ranks easily first as a pest. The crux of this problem is that the full-grown caterpillars of this borer remain dormant in the stubble after harvest; this period of "aestivation" takes at least 4 or 5 months and comes to an end only at the first showers at the beginning of the rainy season. The moths begin to emerge from the stubble four to six weeks after the first shower, and all of them have issued within the following two weeks. On these facts is based the very effective system which Dr. van der Goot has evolved for combating this pest in Java, which consists of the following procedure: (1) where possible and practical late sowing of the seed-beds, at least six weeks after the date of the first showers, is enforced, in order that all moths may have emerged from the stubble, and that later sowings therefore may remain free from infestation. (2) Where late sowing cannot be enforced, rice growers are *advised* about the proper date of transplanting the different varieties in such a way that the period of pre-flowering will not coincide with the emergence of the fourth generation of moths, and in this way serious damage may be evaded.

Other rice borers are considered by Dr. van der Goot to be of little importance in the Dutch East Indies. *Chilo simplex* (Butl.), which occurs also in Hawaii, is rather rare in Java, and Dr. van der Goot considers the egg-parasites, *Trichogramma australicum* Gir. and *T. minutum* Riley, to be the real agency holding *Chilo* in check. Numerous other rice pests, including the rice bug, *Leptocorisa acuta* Thunb., were discussed in this paper.

Dr. Inokichi Kuwana, of Tokyo, presented a paper on "The Rice Stem Borers in Japan." *Chilo simplex* and *Sesamia inferens* Walker are generally distributed throughout the Japanese Empire, the former having two generations annually, feeding upon many gramineous plants in addition to rice, and hibernating in the mature larval stage in the stubble. *Schoenobius incertellus* Walker is confined to Formosa and the southern islands of the Empire, has three generations a year, hibernates in the same stage as *C. simplex,* but confines itself to attacks on the rice plant. Dr. Kuwana listed two egg-parasites and about a dozen larval parasites, all Hymenoptera.

A second paper by Dr. Kuwana was "Important Insect Pests of the Rice

Crop in Japan," in which he discussed in detail the food plants, parasites, and artificial control of the three borers, *S. incertellus, C. simplex* and *Nonagria inferens* Walker. Other pests discussed in similar detail are a leafroller, *Parnara guttata* Brem., four important leafhoppers, and *Podops lurida* Brum., a moth whose larvae feed on the leaves and stem of the plant. Still another paper by the same author discussed the biology of *Trichogramma japonicum* Ashm. and *Phanurus beneficiens* (Zehnt), egg-parasites of the rice stem borers in Japan. In *Phanurus* parthenogenetic reproduction results in male progeny only, in Japan, but Dr. van der Goot stated that in Java this parasite produces only females parthenogenetically. (Since this was written it has been stated by a competent authority that the *Phanurus* of Japan is not *beneficiens,* but another, probably new, species.)

A fourth paper by Dr. Kuwana was entitled "Important Diseases of the Rice Crop in Japan." The most important are: (1) *Piricularia oryzae* Pri. and Car., which has three forms: leaf-blast, affecting young plants; rotten-node, damaging the sheath nodes just above the joints of the stems; and rotten-nick, affecting the stem where it forms the axis of the grain-head; (2) *Helminthosporium oryzae* B. de H.; (3) *Pseudomonas oryzae* Uyeda and Ishiyama; (4) *Hypochnus sasakii* Shir.

Dr. S. Nakayama, of Korea, presented a paper on "The More Important Insect Enemies of the Rice Crop in Chosen," listing ten important pests, including *Chilo simplex,* three species of leafhopper, an armyworm, two flea-beetles, and the grasshopper, *Oxya velox* Fab.

Dr. G. H. Corbett, of the Federated Malay States, submitted a paper, "Brief Notes on Some Padi Insects in Malaya," in which he discussed parasites of *Diatraea auricilia* Dudg. and two other stem borers, the habits and control of the rice bug *Leptocorisa acuta,* and notes on paddy bugs and leaf-feeding caterpillars.

Several other papers which will appear in the Proceedings of the Congress, but presentation of which was impossible due to lack of time, were also submitted. Among them were papers on rice diseases by Dr. C. M. Doyer, and by Dr. P. van der Elst of Java, and by Dr. R. Haskell, of the United States, and a summary of insects affecting rice in the Philippines, by Dr. L. B. Uichanco.

The second meeting of the division was devoted to papers dealing with the improvement of planting material in permanent crops. Prominent among these were: "Improvement of the Coconut Crop by Selection," by Dr. H. W. Jack, of Kuala Lumpur; "The Selection of Oilpalms," by Dr. J. F. Schmole; "The Selection of *Coffea arabica,"* by Dr. J. Schweizer; "The Selection of *Hevea* in Java," by Drs. O. de Vries, J. Schweizer and F. W. Ostendorff; and "The Restoration of the Louisiana Sugarcane Industry through the Adoption of Java Varieties of Cane," by Dr. R. D. Rands.

At the third session of the division, the section on phytopathology met separately. Although numerous papers on insect pests of important crops around the Pacific were submitted at this meeting, the entire time was given up to the discussion of international cooperation in insect control by means of natural enemies. This was based upon a paper by Dr. S. Leefmans, Director of the Institute for Plant Diseases at Buitenzorg, entitled "Cooperation in Parasite Work around the Pacific." In it he advocated the following aids to better cooperation in this important phase of entomology:

1. Interchange of lists of insect parasites and predators between workers in the countries around the Pacific.

2. Publication of full particulars of methods used in importing or sending useful insects from one country to another.

3. Better organization of the systematic side of parasitic work so as to facilitate speedier identification of material, particularly in the groups of parasitic Hymenoptera and Diptera. The majority of those present thought this could best be accomplished by grants of funds to museums which are already established, so as to permit the employment of additional systematists in the groups named.

4. Pushing of such scientific work on insects as is especially important for the further progress of applied entomology. This includes the further study of: the law of tropisms; the influence of climatic conditions; the influence of condition of plant hosts on their insect guests; the causes of monophagy and of polyphagy; the instincts and habits of insects; modes of insect dispersion and the influence of world traffic; relation between food and climate and biological races; the physiological relations between parasites and their hosts; the causes of monophagy and polyphagy in insect parasites; the causes of immunity of insects to parasite attack; the causes of aestivation, hibernation and migration; the causes of extreme multiplication of insects, etc.

As a result of this discussion, the Pacific Science Council presented a resolution, adopted in the final general meeting of the Congress, which provides for the formation of a standing committee on Pacific economic entomology. This committee will probably pay special attention to the points brought out in Dr. Leefman's excellent paper.

Among the twenty-eight resolutions adopted in final general session of the Congress were the following:

Recommendations that the International Code of Zoological Nomenclature be adopted by all workers on taxonomy of both extinct and living animals.

Recommendations for the establishment in the Malay Archipelago of an international marine biological and oceanographical station.

Recommendations for soil surveys and soil classification to be conducted on a uniform basis by all countries around the Pacific.

The Executive Committee announced the formation of a division of medical sciences. The invitation of the Canadian delegation to hold the Fifth Pacific Science Congress in Canada in 1932, was accepted unanimously. Following the closing business meeting, the President's dinner was held in Bandoeng on May 25, 1929.

There followed a week or more of field excursions planned to show the principal features of agriculture in Java, and the geology, zoology, botany, archeology, etc., of the country. One of these trips was to Trinil in eastern Java, where, in 1891, du Bois discovered the remains of the anthropoid, *Pithecanthropus erectus*, the prehistoric, so-called Java man. Another excursion was to the island of Bali, which lies to the east of Java, where an interesting Hindu civilization exists. Finally, on June 4 the Congress was brought to a close by a farewell banquet at Soerabaia.

Delegates Attending the Third Congress of the International Society of Sugar Cane Technologists, Java, 1929

By J. P. Martin

Delegates representing twelve sugar-producing countries of the world were present at the Third Congress of the International Society of Sugar Cane Technologists, which was held in Java, June 7 to 19, 1929.

The countries represented at the Congress are as follows: Australia, Egypt, Hawaii, Indo-China (French), British India, British West Indies, Japan and Formosa, Java, Mauritius, the Philippines, Porto Rico and the United States of America (continental).

The general and sectional meetings were held in Soerabaia, June 7 to 14, while the field excursions, which covered the main sugar-producing districts of Java, extended from June 14 to 19. The delegates were divided into two groups before starting on the field excursions: one group, under the leadership of Dr. V. J. Koningsberger, included the agriculturists, entomologists and pathologists; the other group, under the direction of Dr. E. C. von Pritzelwitz van der Horst, included the technologists, who were interested primarily in factory operation and chemical control.

On the evening of June 19, a farewell dinner was given the delegates at Bandoeng by the General Syndicate of Sugar Manufacturers in the Dutch East Indies.

During the meetings, the writer was able to secure the addresses of all delegates and, with the exception of three, a photograph of each delegate.

The object of this article is mainly to list the various delegates, under the name of the country they represented, with their addresses and photographs.

AUSTRALIA—

1. DR. A. J. GIBSON,
   Bingera Estate,
   Bundaberg, Queensland.
2. DR. H. T. EASTERBY,
   Director, Bureau of Sugar Experiment Stations,
   Brisbane, Queensland.
3. N. BENNETT,
   Sugar Technologist, Bureau of Sugar Experiment Stations,
   Brisbane, Queensland.

EGYPT—

4. P. NEUVILLE,
   Engineer, Raffinerie, Hawamdieh,
   Egypt.

HAWAII—

5. J. W. WALDRON,
   First Vice President, Hawaiian Sugar Planters' Association,
   Chairman, Experiment Station Committee, H.S.P.A.,
   Honolulu, T. H.

6. N. H. BAIRD,
   Theo. H. Davies & Co., Ltd.,
   Honolulu, T. H.

7. L. D. LARSEN,
   Manager, Kilauea Sugar Plantation Company,
   Kilauea, Kauai, T. H.

8. W. W. G. MOIR,
   Agricultural Technologist, American Factors, Ltd.,
   Honolulu, T. H.

9. W. L. McCLEERY,
   Associate Sugar Technologist, Experiment Station, H.S.P.A.,
   Honolulu, T. H.

10. R. A. HUTCHISON,
    Manager, Laupahoehoe Sugar Company,
    Papaaloa, Hawaii, T. H.

11. H. P. AGEE,
    Director, Experiment Station, H.S.P.A.,
    Honolulu, T. H.

12. U. K. DAS,
    Assistant Agriculturist, Experiment Station, H.S.P.A.,
    Honolulu, T. H.

13. W. VAN HEEMSKERCK DUKER,
    Consulting Chemist, Theo. H. Davies & Co., F. A. Schaefer & Co., Ltd., Hawi Mill & Plantation Co., Ltd.
    Honolulu, T. H.

14. DR. A. J. MANGELSDORF,
    Geneticist, Experiment Station, H.S.P.A.,
    Honolulu, T. H.

15. DR. GERTRUDE CASSIDY,
    Assistant Nematologist, Experiment Station, H.S.P.A.,
    Honolulu, T. H.

16. S. S. PECK,
    Manager, Technical Department, Alexander & Baldwin, Ltd.,
    Honolulu, T. H.

17. J. P. MARTIN,
    Pathologist, Experiment Station, H.S.P.A.,
    Honolulu, T. H.

INDO-CHINA (French)—

18. P. VIEILLARD,
    Inspecteur des Services Agricoles,
    Inspection Generale de l'Agriculture,
    Hanoi, Indo-China.

BRITISH INDIA—

19. D. G. WALAWALKAR,
    Chemist and Technologist,
    Malvan, Bombay, India.
20. K. C. BANERJEE,
    Secretary, Sugar Technologists' Association of India,
    67 George Town, Allahabad, India.
12. U. K. DAS (see 12 above).
21. DR. T. S. VENKATRAMAN,
    Government Sugar Cane Expert (Geneticist).
    Imperial Sugar Cane Station,
    Coimbatore, South India.
22. S. J. SABNIS,
    Chemist, Burma Sugar Co., Ltd.,
    Sahnaw, Upper Burma.

BRITISH WEST INDIES—

23. W. SCOTT,
    Sugar Technologist, Imperial College of Tropical Agriculture,
    Trinidad, B. W. I.

JAPAN and FORMOSA—

24. S. KUSAKADO,
    Director and General Superintendent of Taiwan Seito Co.
    (Formosa Sugar Manufacturing Co.)
    Yuraku Bldg., Marunouchi, Tokyo, Japan.
25. DR. K. OSHIMA,
    Professor, Imperial University of Formosa,
    Taihoku, Formosa.
26. *MANABU SAWA,
    Agriculturist, Niitaha Seito Kaisha,
    Tairin, Kagi, Formosa.
27. *TOSHIO SAKAMOTO,
    Geneticist, Shinkwa Sugar Experiment Station,
    Shinkwa, Formosa.

JAVA—

28. DR. P. HONIG,
    Director, Technological Department, Sugar Experiment Station,
    Pasoeroean, Java.
29. *M. HOOLBOOM,
    Consulting Engineer of Anemaet & Co.,
    Soerabaia, Java.

---

* Delegates not shown in the photographs.

30. DR. J. JESWIET,
Professor of Plant Taxonomy, Dendrology and Plant Geography,
College of Agriculture,
Wageningen, Holland.

31. DR. V. J. KONINGSBERGER,
Director, Agricultural Department, Sugar Experiment Station,
Pasoeroean, Java.

32. N. J. PEEREBOOM,
Consulting Agriculturist of Kooy & Company's Administratiekantoor,
Soerabaia, Java.

33. G. M. PERK,
Consulting Chemist of the Ned. Indische Landbouw Maatschappij,
Soerabaia, Java.

34. PROFESSOR E. C. von PRITZELWITZ van der HORST,
Director, Engineering Department, Sugar Experiment Station,
Pasoeroean, Java.

35. PROFESSOR F. A. F. C. WENT,
Professor of Botany,
Utrecht, Holland.

36. DR. G. WILBRINK,
Directress, Cheribon Sub-Experiment Station,
Cheribon, Java.

MAURITIUS—

37. LOUIS BAISSAC,
Technologist, Department of Agriculture,
Reduit, Mauritius.

PHILIPPINE ISLANDS—

38. ADDISON KINNEY,
Assistant Superintendent of Fabrication, San Carlos Milling
Company, San Carlos, Occidental Negros,
Philippine Islands.

39. COLIN W. WADDELL,
Assistant of Fabrication, San Carlos Milling Company,
Occidental Negros, P. I.

40. G. STOWER,
Manager, La Carlota Central,
Occidental Negros, P. I.

41. JUAN O. CHIOCO,
Manila, P. I.

42. DR. MANUAL L. ROXAS,
Agricultural Technologist, Philippine Sugar Association,
Room 316, Roxas Bldg., Manila, P. I.

43. E. T. WESTLY,
Factory Superintendent, Del Carmen Central,
Del Carmen, Pampanga, P. I.

44. H. COSTENOBLE,
Chief Cane Inspector, Pampanga Sugar Mills,
Del Carmen, Pampanga, P. I.

45. L. B. UICHANCO,
Professor of Entomology,
College of Agriculture,
Laguna, P. I.

PORTO RICO—

46. R. FERNANDEZ-GARCIA,
Director, Insular Experiment Station,
Rio Piedras, Porto Rico.

47. M. A. DEL VALLE,
General Superintendent, Central Constancia,
Toa Baja, Porto Rico.

UNITED STATES of AMERICA—
(Continental)

48. DR. F. W. ZERBAN,
Chemist in Charge, New York Sugar Trade Laboratory,
80 South Street, New York City, N. Y.

49. GEORGE ARCENEAUX,
Agronomist in Charge, U. S. Sugar Plant Field Station,
Houma, Louisiana, U. S. A.

50. DR. OSWALD SCHREINER,
Chief, Division Soil Fertility, Bureau Chemistry and Soils,
U. S. Department of Agriculture,
Washington, D. C

51. A. H. ROSENFELD,
Consulting Technologist, American Sugar Cane League,
1005 N. O. Bank Bldg.,
New Orleans, U. S. A.

52. DR. R. D. RANDS,
Senior Pathologist, Sugar Plants,
Bureau of Plant Industry, U. S. Department of Agriculture,
Washington, D. C.

The Executive Committee for the 1929 Congress was composed of the following members:

General Chairman......Dr. J. Jeswiet,
General Secretary......D. L. van Dine (absent from 1929 Congress),
Assistant Secretary.....Dr. V. J. Koningsberger.

The Executive Committee for the 1932 Congress, which is to be held in Porto Rico, is as follows:

General Chairman........................Dr. F. W. Zerban
General Secretary........................A. H. Rosenfeld,
Assistant Secretary......................Manuel A. del Valle.

Many Java members of the Society took a very active part in serving on com-

mittees and presenting papers at the meetings. These members aided greatly in making the Conference a success and their names are listed below, as published in the program of the Congress:

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   Consulting Agriculturist Mij. tot Exploitatie
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   Technologist, Sugar Experiment Station.
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    Agricultural Technologist, Sugar Experiment Station.
11. E. W. CLASON,
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12. DR. J. H. COERT,
    Agricultural Technologist, Sugar Experiment Station.
13. H. W. DANIELS,
    Agricultural Technologist, Sugar Experiment Station.
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    Inspector of Agriculture, Sugar Experiment Station.
16. DR. C. van DILLEWIJN,
    Agricultural Technologist, Sugar Experiment Station.
17. DR. K. DOUWES DEKKER,
    Chemist, Sugar Experiment Station.
18. Ir. J. van DIJK,
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Agricultural Technologist, Sugar Experiment Station.
25. Ir. J. J. W. den HAAN,
Technologist, Sugar Experiment Station.
26. Ir. W. A. HATTINK,
Consulting Engineer, Cultuur, Mij der Vorstenlanden.
27. ING I. HES,
Technologist, Sugar Experiment Station.
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Agent, Internationale Crediet-en Handelsvereeniging "Rotterdam".
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Engineering Agent, "Werkspoor".
33. G. L. HOVENKAMP,
Manager "Gempol-Mills".
34. J. P. F. HUESE,
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35. H. HOUWING,
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36. C. A. J. JOCHEMS,
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37. DR. V. KHAINOVSKY,
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Consulting Engineer, Mijtot Expl. der S. O. Sentanenlor c.s.
39. DR. W. J. C. KOOPER,
Consulting Agriculturist, Internationale Crediet-en Handelsvereenig-ing "Rotterdam".
40. Ir. L. G. LANGGUTH STEUERWALD,
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41. E. H. LAPRE,
42. Ir. G. W. P. LIETH,
Consulting Chemist, Internationale Crediet-en Handelsvereeniging "Rotterdam".

43. J. W. L. van LIGTEN,
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Consulting Chemist, Koloniale Bank.
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47. E. MOOYAART,
Consulting Technologist, Handelsvereeniging "Amsterdam."
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50. Ir. F. Ls. MEYJES,
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52. Ir. G. E. van NES,
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53. P. C. NICOLA,
Technologist, Sugar Experiment Station.
54. DR. A. NIESCHULZ,
Agricultural Technologist, Sugar Experiment Station.
55. Chr. H. NIELSEN,
Consulting Technologist, Handelsvereeniging "Amsterdam".
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Consulting Chemist, Mij. tot Exploitatie der S. O.
Sentanenlor cs.
58. DR. A. RADERMACHER,
Agricultural Technologist, Sugar Experiment Station.
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Superintendent, Sugar-mills.
60. DRS. C. L. RUMKE,
Botanist, Sugar Experiment Station.
61. DRS. R. F. H. SCHMIDT,
Consulting Chemist, Cult. Mij. der Vorstenlanden.
62. Ir. G. J. SCHOTT,
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63. F. SIEWERTS van REESEMA,
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64. Ir. W. A. SNELL,
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65. DR. J. BARON van SLINGELANDT,
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66. P. E. STAVERMAN,
Agent-in-Chief, Koloniale Bank.
67. C. SYLMANS,
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68. Ir. H. J. SPOELSTRA,
Technologist, Sugar Experiment Station.
69. DR. J. G. THIEME,
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70. Ir. L. D. TEUTELINK,
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71. Ir. C. J. TONJES,
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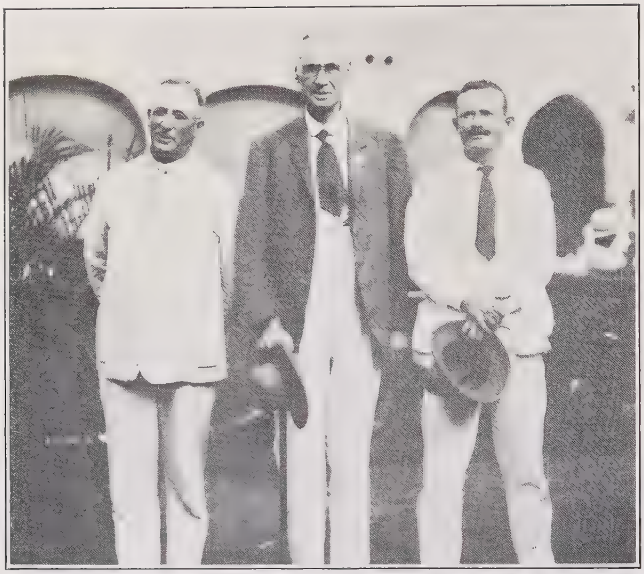
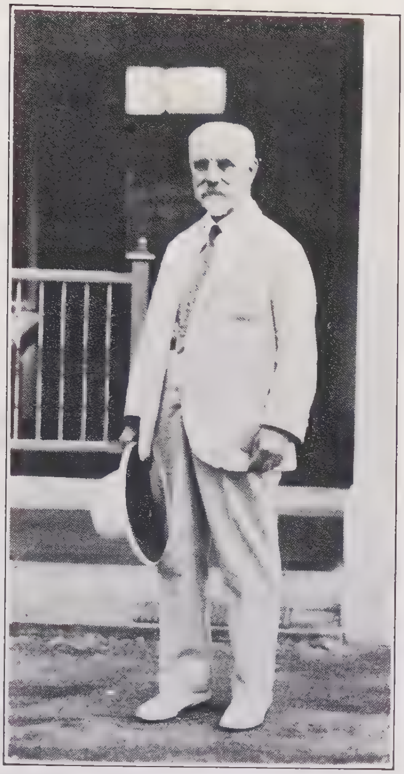
72. W. THOMSON,
Technologist, Sugar Experiment Station.
73. Ir. A. G. WETHMAR,
Agricultural Technologist, Sugar Experiment Station.
74. Ir. J. A. ZANDVELD,
Technisch Bureau J. en C. Vrins.
75. ING H. GERBER,
Irrigation Consulting Technologist Ned. Handel Mij.
76. J. U. F. BENZ,
Treasurer, "General Sugar Organizations".
77. Ir. J. F. BOGTSTRA,
Chemist, Sugar Experiment Station.
78. M. G. MOUT,
Manager, "Watoetoelis-Mills".
79. H. Z. ZEGERS DE BEIJL,
Manager, "Krian-Mills".



1 Gibson — 2 Easterby — 3 Bennett

4 Neuville

5 Waldron



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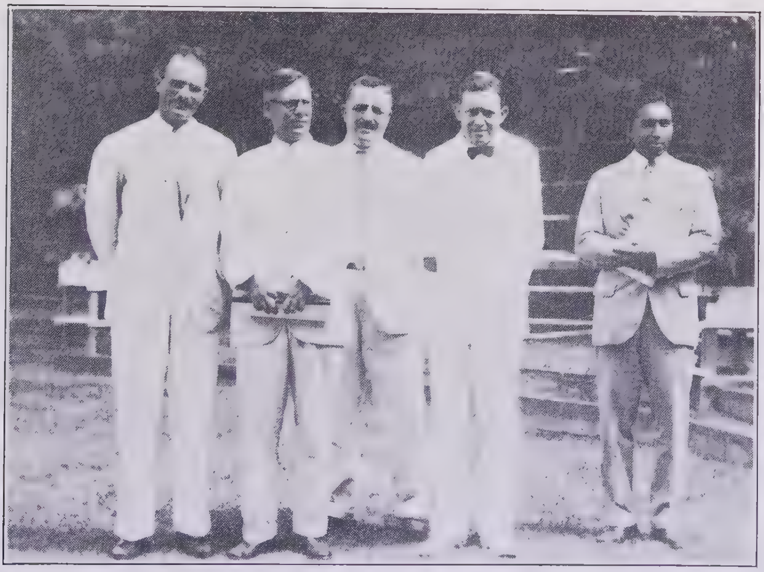
7
Larsen



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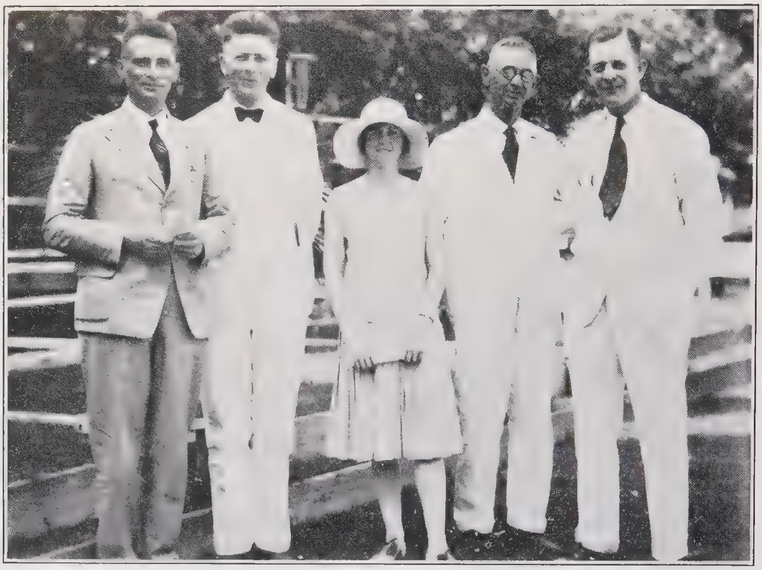

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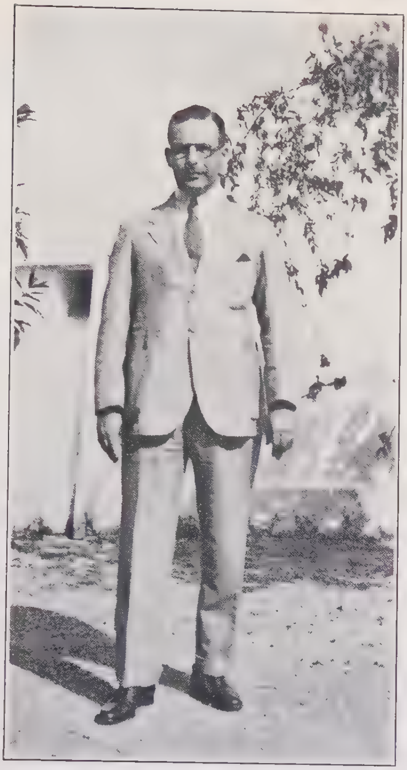
18
Vieillard

19 Walawalkar | 20 Banerjee | 12 Das | 21 Venkatraman | 22 Sabnis



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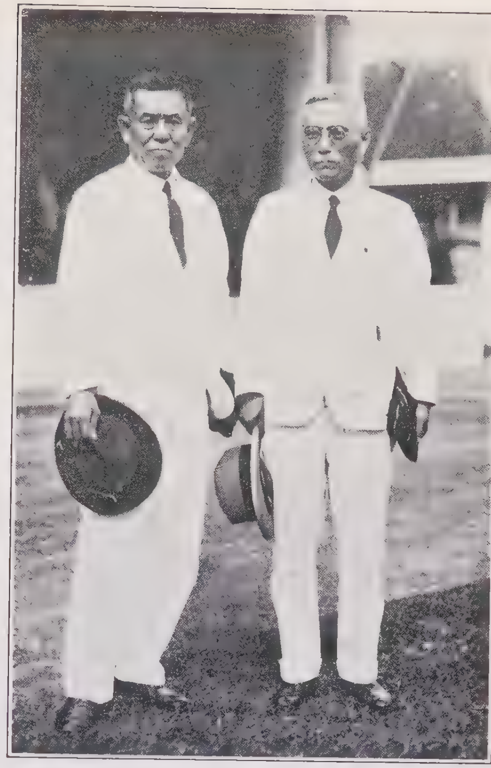

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25
Oshima

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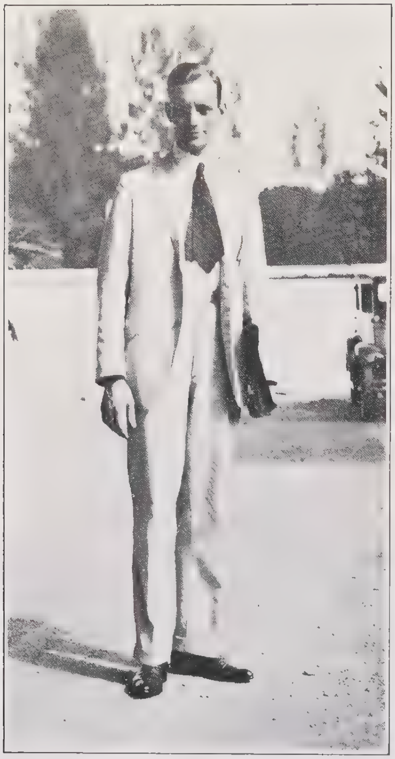
Honig

30
Jeswiet



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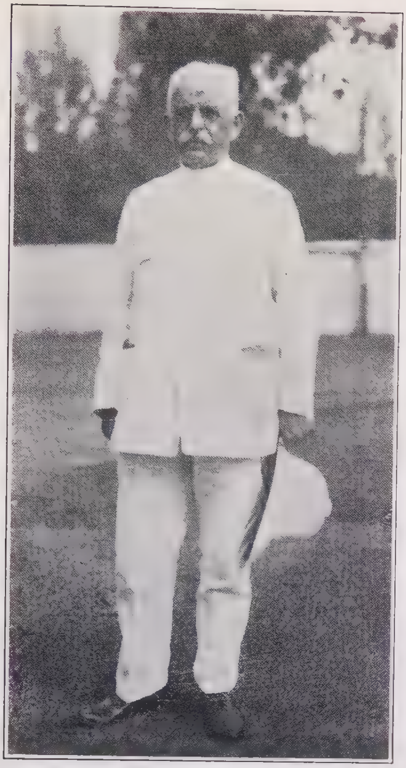
32
Peereboom

33
Perk

34
von Pritzelwitz van der Horst



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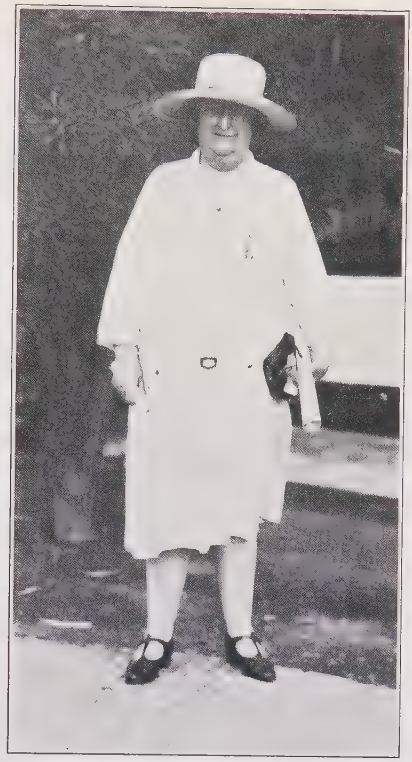

36
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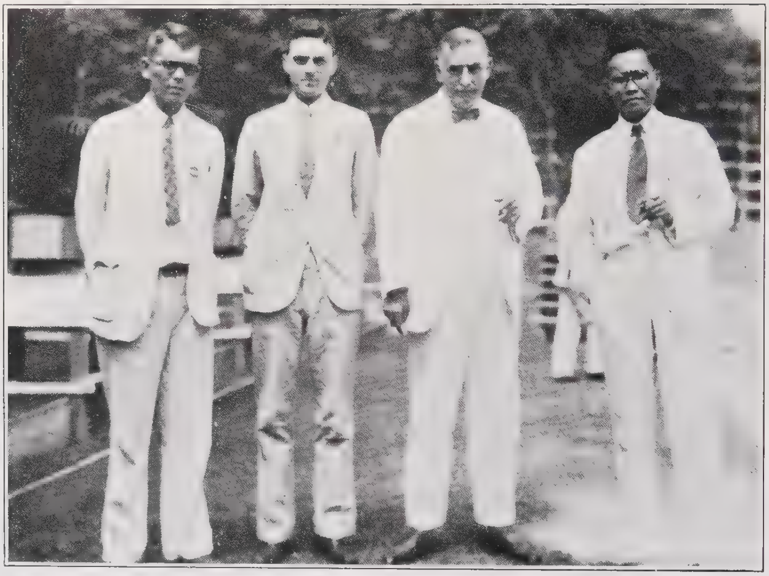
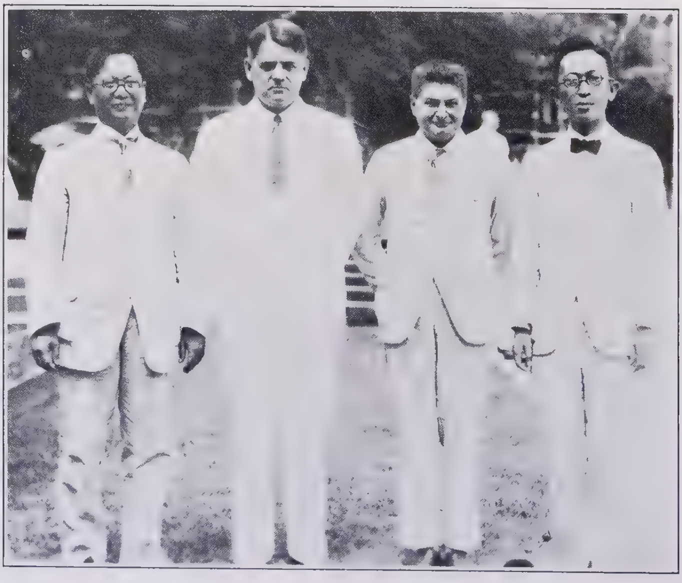
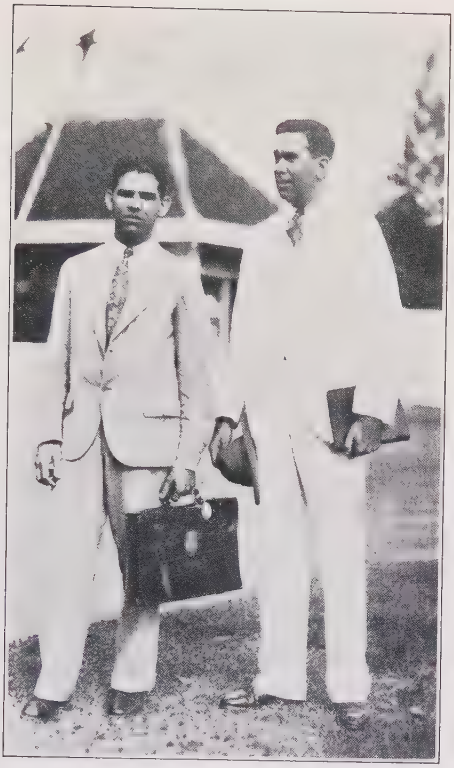
37
Baissac



38 Kinney 39 Waddell 40 Stower 41 Chioco

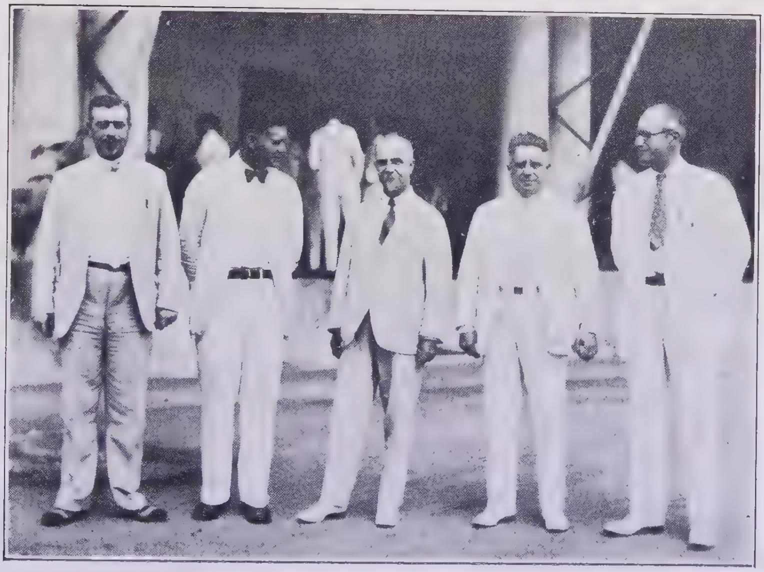


42 Roxas 43 Westly 44 Costenoble 45 Uichanco



46
Fernandez-Garcia

47
del Valle



48
Zerban

49
Arceneaux

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Schreiner

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Rosenfeld

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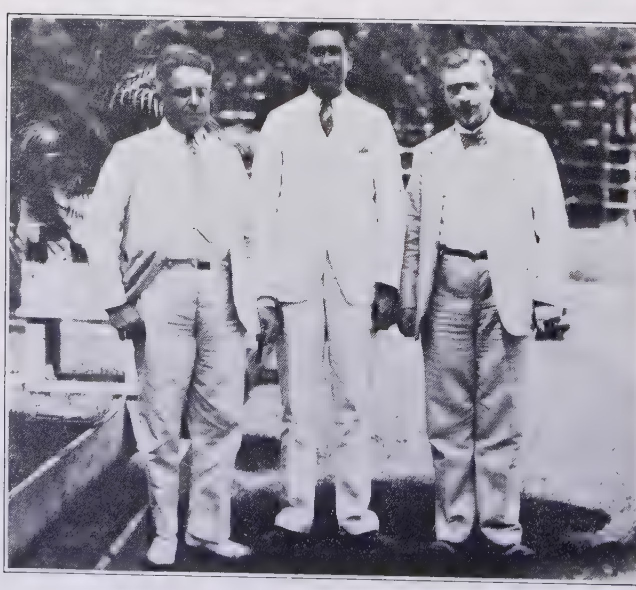
Rands

Executive Committee—1929
Jeswiet Koningsberger



Executive Committee—1932
Rosenfeld del Valle Zerban

Sugar Prices

96° Centrifugals for the Period June 18, 1929, to September 15, 1929.

Date		Per Pound	Per Ton	Remarks
June	18, 1929	3.58¢	$71.60	Porto Ricos.
"	20	3.52	70.40	Cubas.
"	24	3.58	71.60	Cubas.
"	28	3.64	72.80	Cubas.
July	2	3.71	74.20	Cubas.
"	8	3.83	76.60	Cubas.
"	9	3.815	76.30	Cubas, 3.83; Philippines, 3.80.
"	10	3.77	75.40	
"	11	3.83	76.60	Philippines.
"	12	3.86	77.20	Cubas.
"	15	3.89	77.80	Cubas.
"	18	3.99	79.80	Cubas, 4.02; Porto Ricos, 3.96.
"	19	4.02	80.40	Cubas.
"	22	4.05	81.00	Philippines, 4.08; Porto Ricos, 4.02.
"	23	4.02	80.40	Porto Ricos.
"	24	3.975	79.50	Porto Ricos, 3.96; Cubas, 3.99.
"	25	3.89	77.80	Philippines.
Aug.	7	3.83	76.60	Cubas.
"	8	3.77	75.40	Porto Ricos.
"	16	3.83	76.60	Porto Ricos.
"	21	3.77	75.40	Philippines.
"	27	3.83	76.60	Porto Ricos.
"	28	3.815	76.30	Cubas, 3.83, 3.80.
Sept.	4	3.89	77.80	Porto Ricos.
"	9	3.99	79.80	Philippines, 3.96, 4.02.
"	10	4.02	80.40	Philippines.

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An asterisk preceding a page number indicates that the subject is illustrated.

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HAWAIIAN SUGAR PLANTERS' ASSOCIATION

EXPERIMENT STATION STAFF

H. P. AGEE...Director

R. C. L. PERKINS...............................Consulting Entomologist
F. MUIR...Consulting Entomologist
OTTO H. SWEZEY.......................................Entomologist
C. E. PEMBERTON......................................Entomologist
Associate Entomologists: F. X. WILLIAMS, R. H. VAN ZWALUWENBURG. Asst. Nematologist: G. H. CASSIDY. Asst. Entomologist: F. C. HADDEN.

H. L. LYON.................................Botany and Forestry, in charge
Forest Supervisors: L. W. BRYAN (Hawaii), GEORGE A. McELDOWNEY (Oahu), ALBERT DUVEL (Kauai). Assistant Botanist: E. L. CAUM. Supt. Vineyard St. Nursery: JOSEPH E. WIST. Research Assistant: HUGH W. BRODIE. Assistant in Forestry: COLIN POTTER.

W. R. McALLEP......................................Sugar Technologist
Associate Sugar Technologist: W. L. McCLEERY. Assistant Sugar Technologist: RAYMOND ELLIOTT. Technical Chemist: A. BRODIE. Assistant Chemists: H. A. COOK, H. F. BOMONTI, J. H. PRATT, COURTLAND ASHTON. Assistant Chemists in Training: JOHN WHELAN, R. K. HAMILTON.

GUY R. STEWART..Chemist
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J. A. VERRET...Agriculturist
A. J. MANGELSDORF..Geneticist
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J. P. MARTIN...Pathologist
Associate Pathologists: CLYDE C. BARNUM, C. W. CARPENTER. Histologist: D. M. WELLER.

W. TWIGG-SMITH...Illustrator
DARRELL MEEK..Chief Clerk
MABEL FRASER...Librarian

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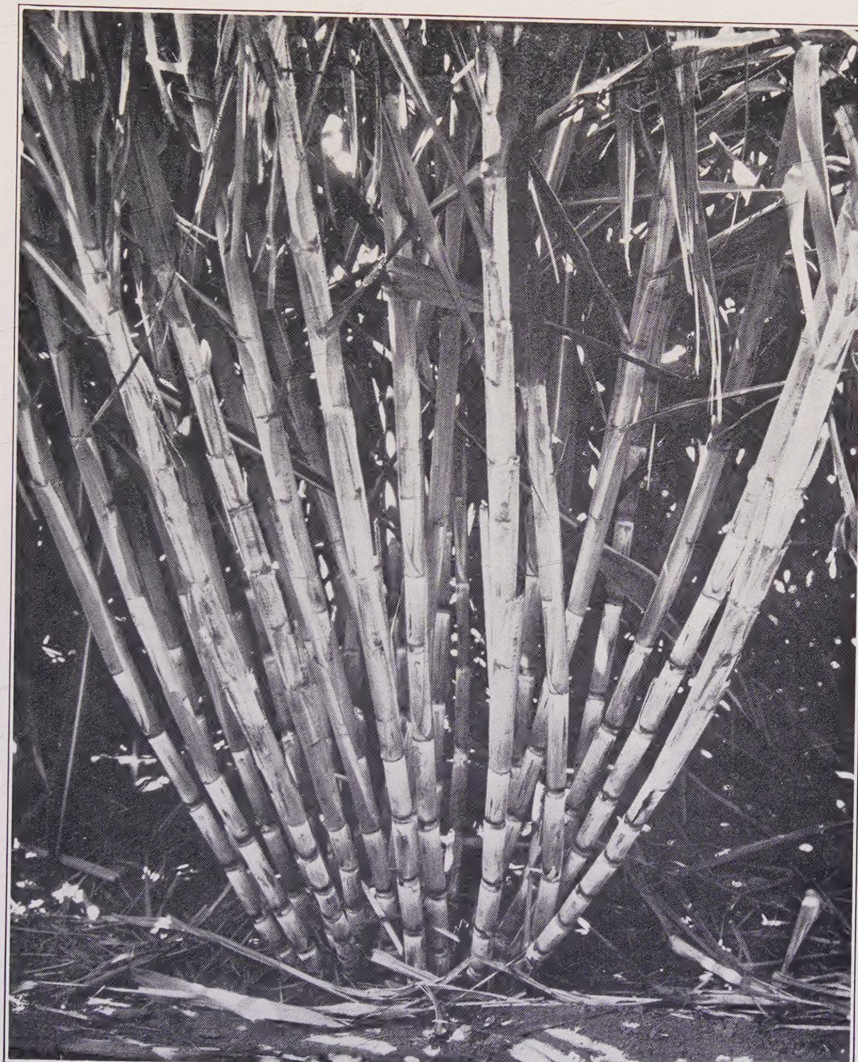
ILLUSTRATIONS APPEARING ON THE COVERS OF VOLUME XXXIII

January

Ficus altissima, one of the most promising of the figs being used in reforestation.



P. O. J. 2878 grown at Kawela, Molokai. Eight months old when harvested on August 9, 1929.

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